JC10 Rec'd PCT/PTO 2 4 AUG 2001 US

FORM PTO-1390 (REV 10-96) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 01-515

U.S. APPLICATION NO (If known, see 37 CFR 1.5): 09/914335

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FR00/00311	February 9, 2000	February 26, 1999

TITLE OF INVENTION
SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH...

APPLICANT(S) FOR DO/EO/US
THIERRY GRENOT

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [XX] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [XX] This express request to begin national examination procedures (35 U.S C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [XX] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [XX] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [XX] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [XX] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). (Informal)
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [XX] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [XX] Other items or information:
    Form PCT/IPEA/416
    Form PCT/RO/101
    Form PCT/IB/332
    Form PCT/IB/308
    Form PCT/IB/304
    Form PCT/IB/301

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, DC 20231

on August 24, 2001
(Date of Deposit)

Nicole Motzer
Name and Reg. No. of Attorney

Nicole Motzer
Signature

August 24, 2001
Date of Signature

EXPRESS MAIL NO.:
EL394335613US

(January 1997)

U S APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/914335	PCT/FR00/00311	01-515

17. [XX] The following fees are submitted:

		CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)): 860.00 Search Report has been prepared by the EPO or JPO .... $9XXXX International preliminary examination fee paid to USPTO (37 CFR 1.482) .... $700.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) ..... $770.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO .... $1040.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $96.00			
ENTER APPROPRIATE BASIC FEE AMOUNT =		$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		$ --	

(See Preliminary Amendment)

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	16 - 20 =	-	X $22.00	$ --	
Independent claims	2 - 3 =	-	X $80.00	$ --	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction of 1/2 for filing by small entity. Applicant claims small entity status.				$ 430.00	
SUBTOTAL =				$ 430.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1 492(f)). +				$ --	
TOTAL NATIONAL FEE =				$ 430.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ --	
TOTAL FEES ENCLOSED =				$ 430.00	
				Amount to be: refunded	$
				charged	$

a. [X] A check in the amount of $ 430.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ______________ in the amount of $____________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-0184. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO
Barry L. Kelmachter
BACHMAN & LaPOINTE, P.C.
900 Chapel Street, Suite 1201
New Haven, CT 06510-2802

Barry L. Kelmachter
SIGNATURE

Barry L. Kelmachter
NAME

29,999
REGISTRATION NUMBER

09/914335
JC03 Rec'd PCT/PTO 24 AUG 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant :	THIERRY GRENOT	Docket No.:	01-515
Serial No. :		Examiner :	
Filed :		Art Unit :	
PCT No. :	PCT/FR00/00311		
IFD :	February 9, 2000		
For :	SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS		

900 Chapel Street
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New Haven, CT 06510-2802

PRELIMINARY AMENDMENT

Hon. Commissioner of Patents and Trademarks
United States Patent and Trademark Office
Washington, D.C. 20231

Dear Sir:

Prior to the initial office action in the above-captioned newly filed patent application, please amend said application as follows:

IN THE SPECIFICATION:

Amend pages 1, 4, 8, 10-14, 17, and 18 as shown in the attached amended pages 1, 1A, 4, 4A, 8, 8A, 10, 11, 12, 13,

13A, 14, 14A, 17, 17A, and 18. A clean copy of the amended pages is also attached hereto.

IN THE DRAWINGS:

Amend FIGS. 1 through 5 and 7 through 16 as shown in red in the attached sketches.

IN THE CLAIMS:

Cancel claims 1 - 12 without prejudice and replace them with the attached new claims 13-28.

REMARKS

By the present Preliminary Amendment, the specification has been amended to conform it with U.S. practice. Further, FIGS. 1 through 5 and 7 through 16 have been amended to provide English translations for the elements designated in French. Still further, former claims 1 - 12 have been replaced by new claims 13 - 28 for reasons other than having to do with patentability issues, namely to more completely set forth the invention and to put the claims into U.S. style format.

An early action on the merits is respectfully solicited.

Should the Examiner believe an additional amendment is needed to place the case in condition for allowance, he/she is invited to contact the undersigned attorney at the telephone number listed below.

No fee is believed to be due as a result of this Preliminary Amendment. Should the Commissioner determine that a fee is due, he is hereby authorized to charge said fee to Deposit Account No. 02-0184.

Respectfully submitted,

THIERRY GRENOT

By Barry L. Kelmachter

Barry L. Kelmachter
Attorney for Applicants

Area Code: 203
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Date: August 24, 2001

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on August 24, 2001
(Date of Deposit)

Nicole Motzer
Name and Reg. No. of Attorney

Nicole Motzer
Signature

August 24, 2001
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EXPRESS MAIL NO.:
EL394335613US

SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS

BACKGROUND OF THE INVENTION

The present invention relates to a non-intrusive method for measuring the loss rates and transfer durations for data in a telecommunication network in packet mode.

The invention is particularly adapted to high volume networks that are operated in non-connected mode. It relates also to a *distributed architecture* system comprising a plurality of flow observation probes arranged in several points in the network, and means for transmitting these measurements to a collecting module which is connected to storage means and means for analyzing the measurements that have been provided.

Packet mode telecommunication networks are characterized in that transmitted information are conveyed in groups referred to as packets, that are substantially made up of one header which contains information for sending a packet through the network as well as data to be transmitted. Such packets are conveyed through the network, and travel, in accordance to what suits the best the latter, through the most diversified transmitting and switching means.

An exemplary packet mode network is the Internet network which is operated with IP protocol (Internet Protocol). As a few examples of transmitting and switching means related to the IP protocol, ISDN (integrated services digital network), FR (Frame Relay), ATM (Asynchronous Transfer Mode), SDH (Synchronous Digital Hierarchy), SONET

(Synchronous Optical network), DWDM (Dense Wavelength Digital Multiplexing) networks, etc., can be found.

close with one another.

The present invention aims to alleviate the above-mentioned drawbacks.

SUMMARY OF THE INVENTION

To this end, one object of the invention is to provide a method and a system with a distributed architecture that allow to measure accurately the transfer durations and loss rates for telecommunication networks in packet mode. The method comprises the steps for performing the measurement operations by a plurality of observing probes that are synchronized and distributed at different points in the network, on data packets which are transmitted through the network, the measurement operations comprising the dating and the identification of the data packets, the measurement results being transmitted from the probes to the collecting module.

The method according to the invention is characterized in that the measurement operations further comprise a classification of the data packets in a homogenous flow, and a counting of the packets in the flow, the measurement results being transmitted from the probes to the collecting module through the network (1), the collecting module performing a correlation between all of the measurement results received from the probes, including the determination of the unidirectional transfer durations per flow or information flow group, and of the loss rate for the packets.

The method according to the invention is advantageous in that it does not require the use of test packets, which permits the achievement of a very wide representativeness of every measurement. It is also advantageous in that a

large number of measurements can be carried out, resulting in a high degree of statistical accuracy. Finally, the number of measurements being carried out can be modulated in

in one flow, the transmitting means of the probes using the network to transmit the measurements carried out to the collecting module, the collecting module comprising means for determining the unidirectional transfer durations per flow or information flow group and the loss rate for the packets.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention will be more fully understood from the following description to be considered as a non-limitative example while referring to the appended drawings, in which:

[-] Figure 1 shows schematically an exemplary embodiment of the invention in a telecommunication network in packet mode;

[-] Figure 2 shows a functional diagram of a system implementing a method according to the invention;

[-] Figure 3 depicts schematically an example of an internal function organization for a system according to the invention;

[-] Figure 4 shows a functional diagram depicting the operation of an observing probe used in a system according to the invention;

[-] Figure 5 shows a functional diagram depicting the operation of a collecting module used in a system according to the invention; and

[-] Figure 6 to 15 depict schematically the operation of a system according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In Fig. 1, there is shown schematically a high volume network 1 that is operated in non-connected mode, such as a

network based on IP protocol (Internet Protocol). A plurality of flow-observing probes 2_i are arranged at different points in the network for carrying out measurements on flows of data that are exchanged through this network. Means for compressing

each packet they have access to. These measurements consist in performing dating, classification and identification of the packets, as well as compressing these measurements. Every probe 2_i transmits, through the network 1, the compressed measurements to the collecting module 4 that correlates all of these measurements.

Other embodiments are also possible in the scope of the invention, notably in the following cases:

- the users 8_i are not necessarily end users for information being conveyed within the packets; for instance, they may represent local networks or other networks in packet mode;
- the probes [2i] $\underline{2_i}$ can be connected to the collecting module 4 through means other than the network 1; for instance, through another telecommunication network, or through a local storage medium that stores data from the collecting module 4, sending them back to it later on;
- the same collecting module 4 can be connected to several collecting modules 4;
- several collecting modules 4 can communicate to build up correlations between measurement elements they have.

As an example, a possible functional diagram of the system according to the invention is shown in Fig. 3. Four functional groups can be found therein:

- the rule group 10, with the rules being fixed statically or semi-statically (for example by the system operator);
- the load evaluation group 20, measuring the load rate on the local central processing unit, the memory occupancy, etc...;
- the calculation group 30, evaluating dynamically the values relating to compaction, sampling, etc...;

- the data path group 40, producing records that contain combinations (class, date, signature) for each packet.

When activated, the probes 2_i gain a common time reference 31. The inaccuracy of this reference between two probes 2_i affects directly the accuracy of the result for the whole device. Means for gaining that time reference can be diversified as well as multiple; as non-limitative examples, GPS (Global Positioning System), broadcasting through radio waves, high stability drivers, NTP (Network Time Protocol) and SNTP (Simple Network Time Protocol) protocols may be mentioned;

- each packet is subjected to dating 41 using the absolute time reference when it is observed by a probe [2i] $\underline{2_i}$. The latter is able to date, either the start of the packet, or the end of the packet, or any other criterion.
- each packet is subjected to the calculation of the signature 42, that is for representing it later on. The signature enables to reduce the amount of information which is needed to identify the packet. That signature results typically from a binary polynomial calculation (for instance, CRC calculation - cyclic redundancy check - on 16 or 32 bit elements). The signature calculation is performed either on the whole packet or on a part of it, in accordance to what is contemplated in relation with the structure and the variability of the contents of the packets in the network. The signature has to be small compared to the mean pocket size, so as to ease its storage, its transmission and its subsequent processing. It must be capable of assuming different values to make negligible the likelihood that two different packets have the same signature. As an example, it

can be considered that one signature on 16 bit elements enables to identify about 256 different packets with a low likelihood of ambiguity;

- each packet is subjected to a classification operation 44. Criteria for classification are typically those that are conventionally retained to identify flows between networks and sub-networks (such as IP network sub-addresses), flows between end equipment (such as IP addresses), flows between applications (such as IP addresses and UDP/TCP transport addresses), etc... Each packet is then identified by combining all or part of the elements : class, date, signature;
- each class can be subjected to filtering 45; i.e., the probes [2i] $\underline{2}_i$ do not store the combinations (class, date, signature) for packets belonging to one of the classes for which the filter has been provided;
- each class can be subjected to a compaction or a semi-static sampling operation 46. In this case, only a part of the combinations (class, date, signature) for packets belonging to a given class will be retained. The sampling rate depends typically of the class, and will not theoretically change dynamically. For instance, it may be desirable to keep all of the combinations of packets conveying voice, and only a part of those conveying computer files.
- each class can be subjected to a dynamic sampling with a rate which depends of the congestion conditions in the system : measurement of the occupancy of buffers 21 and memories 22 of the probes [2i] $\underline{2}_i$, transmission flow rates towards the collecting module 4, network load, load of the collecting module 4, etc... A multiplicity of criteria can be used so that the overall operation

can take place automatically in an area that suits the best the device administrator. For instance, the highest sampling rate for a given maximum flow rate of a flow brought back from the probe to the collector, or a minimum flow rate of a flow brought back to the collector for a given sampling rate;

- a counter is associated with each combination (class, date, signature) that is retained, indicating the number of packets observed in the flow. The collecting module 4 is then capable to measure the loss rate in the network by comparing between the counters associated with the same packets at different points in the network.

The filtering and static and dynamic sampling operations allow to reduce the amount of combinations (class, date, signature) to be stored [et] and processed. The provision or removal of filters, the values of the semi-static sampling rates, the parameterization the dynamic sampling, etc..., can be achieved, for instance, through an administrative operation performed from one of the collecting modules 4 or operating modules 7.

Sampling criteria can be diversified. As examples, periodical sampling which consists in keeping one combination every N combinations, statistical sampling that depends on drawing a random variable of which statistical characteristics are under control, and sampling on signature that consists in keeping only those combinations of which the signatures belong to a given set of values can be mentioned.

The sequence order through which a probe 2_i performs the above-mentioned operations may change. A probe 2_i can classify the packets before dating them, as long as the measurement accuracy is not altered to a great extent. In

the same way, the filtering operations can be performed at different instants during the process.

Fig. 5 depicts the steps for collecting and correlating the measurements by a collecting module 4.

The latter receives samples of the non-filtered combinations (class, date, signature) originating from all of the observing probes 2_i attached therewith;

- each packet is theoretically seen by two observing probes [2i] $\underline{2_i}$: the first time when entering the network, the second time when leaving. However, other situations may occur. For instance, one packet might be seen only once if the supervision domain is not closed, or more than twice if there are observing probes [2i] $\underline{2_i}$ within the network;
- each time a packet has been observed by an observing probe [2i] $\underline{2_i}$ as passing by, one combination (class, date, signature) is received by the collecting module 4, except when filtering, sampling or loss of return message, etc..., is taking place;
- the collecting module 4 correlates the combinations (class, date, signature) for the same packet, for instance by comparing between the signatures and by increasing the transit delays in the network;
- in case of success, it infers from above, through a simple arithmetical calculation, on one hand, the transfer duration between the different observing probes [2i] $\underline{2_i}$ for the packet in question and on the other hand, the number of packets that were possibly lost in the network. Moreover, a number of packets in excess at the exit enables to indicate that a fault in one of the network devices or an intrusion attempt has occurred. More sophisticated calculations, such as mean, minimum, maximum, median, etc..., values for a given time slot and

a certain flow type, can also be achieved in the collecting module 4 prior to the storage operation

It is to be noted that sampling do not reduce the counting accuracy. This is equally true when packets are lost, that otherwise would have cause tickets to be issued. Actually, the counter that is associated with every ticket produced yields the total number of packets since the last sampled ticket. The only consequence is a loss of accuracy as for the precise instant at which the loss occurred and the exact identity of the packet that was lost. Both characteristics are of little usefulness a priori, thus being not much looked after. However, as the sampling characteristics are attached to a certain flow, it is always possible not to sample the flows for which detailed information are desirable. For those flows, all of the packets will cause one ticket to be issued. Moreover, as the number of measurements is lower than the number of packets, statistical laws will be applicable, that are well known as for the validity and the accuracy of the measurements which are applied to the sample thus captured.

Therefore, the method according to the invention enables to achieve flow control at the probe level in order:

- to protect the collecting module 4 against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size,...);
- to protect the probes [2i] $\underline{2}_i$ against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size,...);
- to protect the network used to transmit ticket records from the probe to the collector;

- to adapt to changes in the capacity of the network used to transmit ticket records from the probes [2i] <u>2_i</u> to the collecting module 4;

- to enable an optimum distribution of the measurement resource between the different flows in case of congestion;
- to optimize the pair (measurement accuracy/network load) in accordance with combined criteria, in normal operation.

To control the flow, the following functions may by used, separately or in combination:

- limitation of the overall flow through the network to a maximum value due to the transmission of ticket records from the probes [2i] $\underline{2_i}$ to the collecting module 4. That limit can, either be defined by an initial configuration, or be modulated by the collecting module 4 or by an external device operating the network;
- limitation of the sampling rate to a maximum value. That limit can, either be defined by an initial configuration, or be provided by the collecting module 4 or by an external device operating the network. In addition, it may differ from each type of flow or flow group;
- reduction of the sampling rate. That reduction can, either be defined locally by observing the congestion of the probes [2i] $\underline{2_i}$, or be fixed by the collecting module 4 or by an external device operating the network. That reduction may differ for each type of flow or flow group. The reduction law must allow the collection module 4 to correlate records which were performed by probes 2i $\underline{2_i}$ having not the same sampling value for a given flow, the reduction being not necessarily synchronous between the probes [2i] $\underline{2_i}$. A principle which must be retained is the inclusion one; tickets of the "reduced" flows having to be included also in the tickets of the "lesser reduced" flows. In this way, tickets of the probe 2_i having the highest reduction factor

SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS

BACKGROUND OF THE INVENTION

The present invention relates to a non-intrusive method for measuring the loss rates and transfer durations for data in a telecommunication network in packet mode.

The invention is particularly adapted to high volume networks that are operated in non-connected mode. It relates also to a *distributed architecture* system comprising a plurality of flow observation probes arranged in several points in the network, and means for transmitting these measurements to a collecting module which is connected to storage means and means for analyzing the measurements that have been provided.

Packet mode telecommunication networks are characterized in that transmitted information are conveyed in groups referred to as packets, that are substantially made up of one header which contains information for sending a packet through the network as well as data to be transmitted. Such packets are conveyed through the network, and travel, in accordance to what suits the best the latter, through the most diversified transmitting and switching means.

An exemplary packet mode network is the Internet network which is operated with IP protocol (Internet Protocol). As a few examples of transmitting and switching means related to the IP protocol, ISDN (integrated services digital network), FR (Frame Relay), ATM (Asynchronous Transfer Mode), SDH (Synchronous Digital Hierarchy), SONET

(Synchronous Optical network), DWDM (Dense Wavelength Digital Multiplexing) networks, etc., can be found.

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The present invention aims to alleviate the above-mentioned drawbacks.

SUMMARY OF THE INVENTION

To this end, one object of the invention is to provide a method and a system with a distributed architecture that allow to measure accurately the transfer durations and loss rates for telecommunication networks in packet mode. The method comprises the steps for performing the measurement operations by a plurality of observing probes that are synchronized and distributed at different points in the network, on data packets which are transmitted through the network, the measurement operations comprising the dating and the identification of the data packets, the measurement results being transmitted from the probes to the collecting module.

The method according to the invention is characterized in that the measurement operations further comprise a classification of the data packets in a homogenous flow, and a counting of the packets in the flow, the measurement results being transmitted from the probes to the collecting module through the network (1), the collecting module performing a correlation between all of the measurement results received from the probes, including the determination of the unidirectional transfer durations per flow or information flow group, and of the loss rate for the packets.

The method according to the invention is advantageous in that it does not require the use of test packets, which permits the achievement of a very wide representativeness of every measurement. It is also advantageous in that a

large number of measurements can be carried out, resulting in a high degree of statistical accuracy. Finally, the number of measurements being carried out can be modulated in

in one flow, the transmitting means of the probes using the network to transmit the measurements carried out to the collecting module, the collecting module comprising means for determining the unidirectional transfer durations per flow or information flow group and the loss rate for the packets.

BRIEF DESCRIPTION OF THE DRAWINGS

Other characteristics and advantages of the invention will be more fully understood from the following description to be considered as a non-limitative example while referring to the appended drawings, in which:

Figure 1 shows schematically an exemplary embodiment of the invention in a telecommunication network in packet mode;

Figure 2 shows a functional diagram of a system implementing a method according to the invention;

Figure 3 depicts schematically an example of an internal function organization for a system according to the invention;

Figure 4 shows a functional diagram depicting the operation of an observing probe used in a system according to the invention;

Figure 5 shows a functional diagram depicting the operation of a collecting module used in a system according to the invention; and

Figure 6 to 15 depict schematically the operation of a system according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In Fig. 1, there is shown schematically a high volume network 1 that is operated in non-connected mode, such as a

network based on IP protocol (Internet Protocol). A plurality of flow-observing probes 2_i are arranged at different points in the network for carrying out measurements on flows of data that are exchanged through this network. Means for compressing

each packet they have access to. These measurements consist in performing dating, classification and identification of the packets, as well as compressing these measurements. Every probe 2_i transmits, through the network 1, the compressed measurements to the collecting module 4 that correlates all of these measurements.

Other embodiments are also possible in the scope of the invention, notably in the following cases:

- the users 8_i are not necessarily end users for information being conveyed within the packets; for instance, they may represent local networks or other networks in packet mode;
- the probes 2_i can be connected to the collecting module 4 through means other than the network 1; for instance, through another telecommunication network, or through a local storage medium that stores data from the collecting module 4, sending them back to it later on;
- the same collecting module 4 can be connected to several collecting modules 4;
- several collecting modules 4 can communicate to build up correlations between measurement elements they have.

As an example, a possible functional diagram of the system according to the invention is shown in Fig. 3. Four functional groups can be found therein:

- the rule group 10, with the rules being fixed statically or semi-statically (for example by the system operator);
- the load evaluation group 20, measuring the load rate on the local central processing unit, the memory occupancy, etc...;
- the calculation group 30, evaluating dynamically the values relating to compaction, sampling, etc...;

- the data path group 40, producing records that contain combinations (class, date, signature) for each packet.

When activated, the probes 2_i gain a common time reference 31. The inaccuracy of this reference between two probes 2_i affects directly the accuracy of the result for the whole device. Means for gaining that time reference can be diversified as well as multiple; as non-limitative examples, GPS (Global Positioning System), broadcasting through radio waves, high stability drivers, NTP (Network Time Protocol) and SNTP (Simple Network Time Protocol) protocols may be mentioned;

- each packet is subjected to dating 41 using the absolute time reference when it is observed by a probe 2_i. The latter is able to date, either the start of the packet, or the end of the packet, or any other criterion.
- each packet is subjected to the calculation of the signature 42, that is for representing it later on. The signature enables to reduce the amount of information which is needed to identify the packet. That signature results typically from a binary polynomial calculation (for instance, CRC calculation - cyclic redundancy check - on 16 or 32 bit elements). The signature calculation is performed either on the whole packet or on a part of it, in accordance to what is contemplated in relation with the structure and the variability of the contents of the packets in the network. The signature has to be small compared to the mean pocket size, so as to ease its storage, its transmission and its subsequent processing. It must be capable of assuming different values to make negligible the likelihood that two different packets have the same signature. As an example, it

can be considered that one signature on 16 bit elements enables to identify about 256 different packets with a low likelihood of ambiguity;

- each packet is subjected to a classification operation 44. Criteria for classification are typically those that are conventionally retained to identify flows between networks and sub-networks (such as IP network sub-addresses), flows between end equipment (such as IP addresses), flows between applications (such as IP addresses and UDP/TCP transport addresses), etc... Each packet is then identified by combining all or part of the elements : class, date, signature;
- each class can be subjected to filtering 45; i.e., the probes 2_i do not store the combinations (class, date, signature) for packets belonging to one of the classes for which the filter has been provided;
- each class can be subjected to a compaction or a semi-static sampling operation 46. In this case, only a part of the combinations (class, date, signature) for packets belonging to a given class will be retained. The sampling rate depends typically of the class, and will not theoretically change dynamically. For instance, it may be desirable to keep all of the combinations of packets conveying voice, and only a part of those conveying computer files.
- each class can be subjected to a dynamic sampling with a rate which depends of the congestion conditions in the system : measurement of the occupancy of buffers 21 and memories 22 of the probes 2_i, transmission flow rates towards the collecting module 4, network load, load of the collecting module 4, etc... A multiplicity of criteria can be used so that the overall operation

can take place automatically in an area that suits the best the device administrator. For instance, the highest sampling rate for a given maximum flow rate of a flow brought back from the probe to the collector, or a minimum flow rate of a flow brought back to the collector for a given sampling rate;

- a counter is associated with each combination (class, date, signature) that is retained, indicating the number of packets observed in the flow. The collecting module 4 is then capable to measure the loss rate in the network by comparing between the counters associated with the same packets at different points in the network.

The filtering and static and dynamic sampling operations allow to reduce the amount of combinations (class, date, signature) to be stored and processed. The provision or removal of filters, the values of the semi-static sampling rates, the parameterization the dynamic sampling, etc..., can be achieved, for instance, through an administrative operation performed from one of the collecting modules 4 or operating modules 7.

Sampling criteria can be diversified. As examples, periodical sampling which consists in keeping one combination every N combinations, statistical sampling that depends on drawing a random variable of which statistical characteristics are under control, and sampling on signature that consists in keeping only those combinations of which the signatures belong to a given set of values can be mentioned.

The sequence order through which a probe 2_i performs the above-mentioned operations may change. A probe 2_i can classify the packets before dating them, as long as the measurement accuracy is not altered to a great extent. In

the same way, the filtering operations can be performed at different instants during the process.

Fig. 5 depicts the steps for collecting and correlating the measurements by a collecting module 4.

The latter receives samples of the non-filtered combinations (class, date, signature) originating from all of the observing probes 2_i attached therewith;

- each packet is theoretically seen by two observing probes 2_i : the first time when entering the network, the second time when leaving. However, other situations may occur. For instance, one packet might be seen only once if the supervision domain is not closed, or more than twice if there are observing probes 2_i within the network;
- each time a packet has been observed by an observing probe 2_i as passing by, one combination (class, date, signature) is received by the collecting module 4, except when filtering, sampling or loss of return message, etc..., is taking place;
- the collecting module 4 correlates the combinations (class, date, signature) for the same packet, for instance by comparing between the signatures and by increasing the transit delays in the network;
- in case of success, it infers from above, through a simple arithmetical calculation, on one hand, the transfer duration between the different observing probes 2_i for the packet in question and on the other hand, the number of packets that were possibly lost in the network. Moreover, a number of packets in excess at the exit enables to indicate that a fault in one of the network devices or an intrusion attempt has occurred. More sophisticated calculations, such as mean, minimum, maximum, median, etc..., values for a given time slot and a certain flow

type, can also be achieved in the collecting module 4 prior to the storage operation

It is to be noted that sampling do not reduce the counting accuracy. This is equally true when packets are lost, that otherwise would have cause tickets to be issued. Actually, the counter that is associated with every ticket produced yields the total number of packets since the last sampled ticket. The only consequence is a loss of accuracy as for the precise instant at which the loss occurred and the exact identity of the packet that was lost. Both characteristics are of little usefulness a priori, thus being not much looked after. However, as the sampling characteristics are attached to a certain flow, it is always possible not to sample the flows for which detailed information are desirable. For those flows, all of the packets will cause one ticket to be issued. Moreover, as the number of measurements is lower than the number of packets, statistical laws will be applicable, that are well known as for the validity and the accuracy of the measurements which are applied to the sample thus captured.

Therefore, the method according to the invention enables to achieve flow control at the probe level in order:

- to protect the collecting module 4 against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size,...);
- to protect the probes 2_i against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size,...);
- to protect the network used to transmit ticket records from the probe to the collector;

- to adapt to changes in the capacity of the network used to transmit ticket records from the probes 2_i to the collecting module 4;

- to enable an optimum distribution of the measurement resource between the different flows in case of congestion;
- to optimize the pair (measurement accuracy/network load) in accordance with combined criteria, in normal operation.

To control the flow, the following functions may by used, separately or in combination:

- limitation of the overall flow through the network to a maximum value due to the transmission of ticket records from the probes 2_i to the collecting module 4. That limit can, either be defined by an initial configuration, or be modulated by the collecting module 4 or by an external device operating the network;
- limitation of the sampling rate to a maximum value. That limit can, either be defined by an initial configuration, or be provided by the collecting module 4 or by an external device operating the network. In addition, it may differ from each type of flow or flow group;
- reduction of the sampling rate. That reduction can, either be defined locally by observing the congestion of the probes 2_i, or be fixed by the collecting module 4 or by an external device operating the network. That reduction may differ for each type of flow or flow group. The reduction law must allow the collection module 4 to correlate records which were performed by probes 2i 2_i having not the same sampling value for a given flow, the reduction being not necessarily synchronous between the probes 2_i. A principle which must be retained is the inclusion one; tickets of the "reduced" flows having to be included also in the tickets of the "lesser reduced" flows. In this way, tickets of the probe 2_i having the highest reduction factor

09/914335
JC03 Rec'd PCT/PTO 24 AUG 2001

NEW CLAIMS

13. A non-intrusive method for measuring loss rates and transfer durations for data in a telecommunication network in packet mode comprising the steps of:

performing measurement operations with a plurality of observing probes that are synchronized and distributed at different points in the network on data packets which are being transmitted through the network;

said performing step comprising dating and identifying the data packets;

transmitting measurement results from said dating and identifying step from said probes to a collecting module;

said performing step further comprising classifying the data packets in a homogeneous flow and counting the data packets in the homogeneous flow and transmitting measurement results from said classifying and counting steps from said probes to said collecting module through the network; and

performing with the collecting module a correlation between all of said measurement results received from the probes including determining unidirectional transfer durations per flow or information flow group and the loss rate for the data packets.

14. A method according to claim 13, further comprising said identifying step comprising calculating an identification signature on packet contents for each said data packet.

15. A method according to claim 13, further comprising said dating step comprising subjecting each observed data packet to dating in accordance with an absolute time reference gained by the observing probes.

16. A method according to claim 15, further comprising issuing one ticket comprising packet passage time, packet signature, and a value of a counter associated with the flow or the information flow group.

17. A method according to claim 16, further comprising a filtering step and a semi-static sampling step for classes obtained during the classifying step and said sampling step comprising selecting those data packets which will cause said one ticket to be issued.

18. A method according to claim 17, further comprising a dynamic sampling step with a rate which depends on congestion conditions in the network.

19. A method according to claim 17, wherein said sampling step is performed with a sampling rate which can be limited to a maximum value that is defined by an initial configuration or be modulated by the collecting module or by an external device operating the network.

20. A method according to claim 18, wherein said sampling step is performed with a sampling rate which can be limited to a maximum value that is defined by an initial configuration or be modulated by the collecting module or by an external device operating the network.

21. A method according to claim 13, wherein said classifying step comprises classifying each said data packet according to recipient characteristics of the respective data packet or according to a contents type for the respective data packet.

22. A method according to claim 13, wherein for a given flow F, the transfer durations determining step is carried out as follows:

$$D_{es}(p) = Hs(p) - He(p)$$

where $D_{es}(p)$ is a transfer duration from an entry point (e) to an exit point (s) for a respective data packet (p); He(p) is a first time stamping in a ticket associated with the respective data packet (p) by one of said probes at the entry point; and Hs(p) is a second time stamping in the ticket associated with the respective data packet (p) by said one of said probes at the exit point.

23. A method according to claim 13, further comprising calculating the transfer durations at different sections in the network using a mapping operation of combinations which belong to one of said data packets that has been observed by several of said probes.

24. A method according to claim 13, wherein, for a given flow, the loss rate determining step comprises calculating a number Pes(pq) of said data packets lost in the network between a passage of two data packets designated p and q according to the following formula:

$$Pes(pq) = Ne(pq) - Ns(pq)$$

where $Ne(pq)$ = number of data packets between the passage of the packets p and q at an exit point; and $Ns(pq)$ = number of packets between the passage of the packets p and q at an entry point.

25. A method according to claim 19, wherein, in the case where the sampling rate is low, breaking down time in slots starting from an instant when an observed data packet causes one last ticket to be issued, fixing the size of each time slot locally at one of the probes or by the collecting module, associating one counter with each time slot, and, for every data packet passing by that does not cause one ticket to be issued, incrementing said one counter associated with a corresponding time slot when the passage occurred, and for the next packet passing by that causes one ticket to be issued, attaching a list of counters thereby obtained.

26. A system with a distributed architecture for measuring non-intrusively loss rates and transfer durations for data in a telecommunication network in a packet mode, said system comprising:

a plurality of flow observing probes arranged in several locations in the network;

means for transmitting measurements from said probes to a collecting module including means for analyzing said measurements;

each of said probes further comprising means for classifying data packets in a homogeneous flow, means for identifying each said data packet, means for counting the data packets in one flow;

said transmitting means using the network to transmit the measurements carried out by the probes to the collecting module; and

the collecting module comprising means for determining unidirectional transfer durations per flow or information flow group and the loss rate for the data packets.

27. A system according to claim 26, wherein the identifying means of each said probe comprises means for calculating an identification for each said data packet.

28. A system according to claim 26, wherein each said probe further comprises means for compressing the measurements before transmitting said measurements to the collecting module.

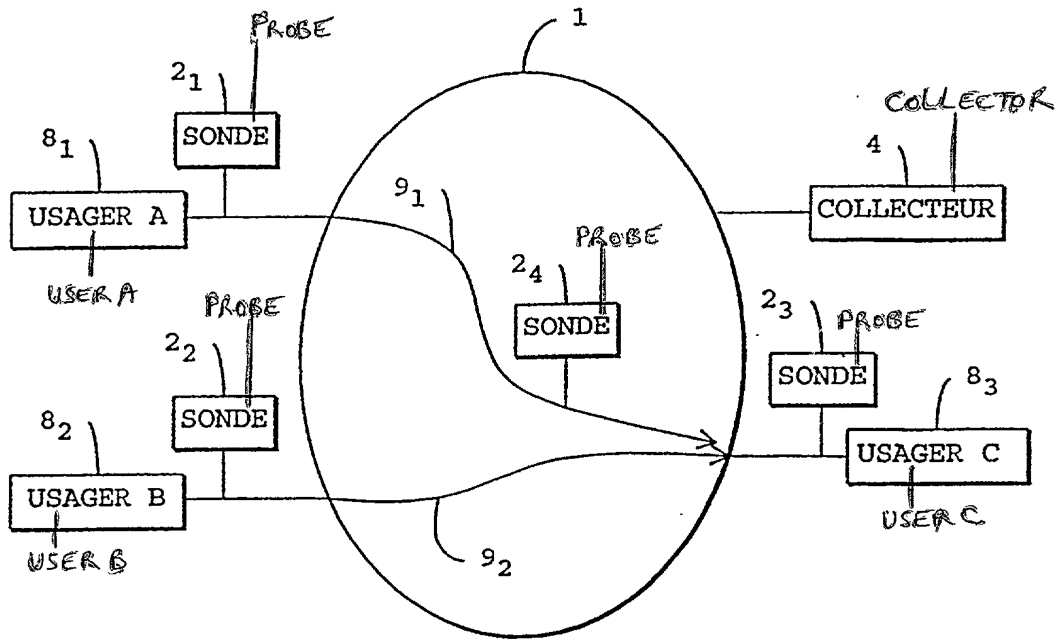

1
PROBE
2_1
SONDE
COLLECTOR
4
COLLECTEUR
8_1
USAGER A
USER A
9_1
PROBE
2_4
SONDE
PROBE
2_2
SONDE
2_3
PROBE
SONDE
8_3
8_2
USAGER C
USER C
USAGER B
USER B
9_2

FIG1

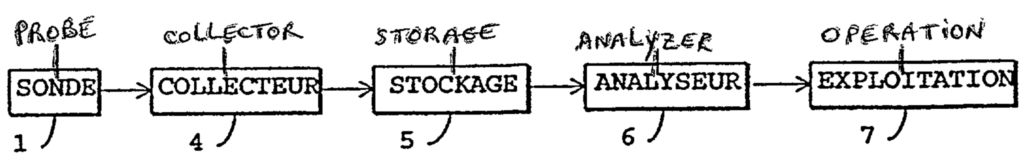

PROBE
COLLECTOR
STORAGE
ANALYZER
OPERATION
SONDE
COLLECTEUR
STOCKAGE
ANALYSEUR
EXPLOITATION
1
4
5
6
7

FIG 2

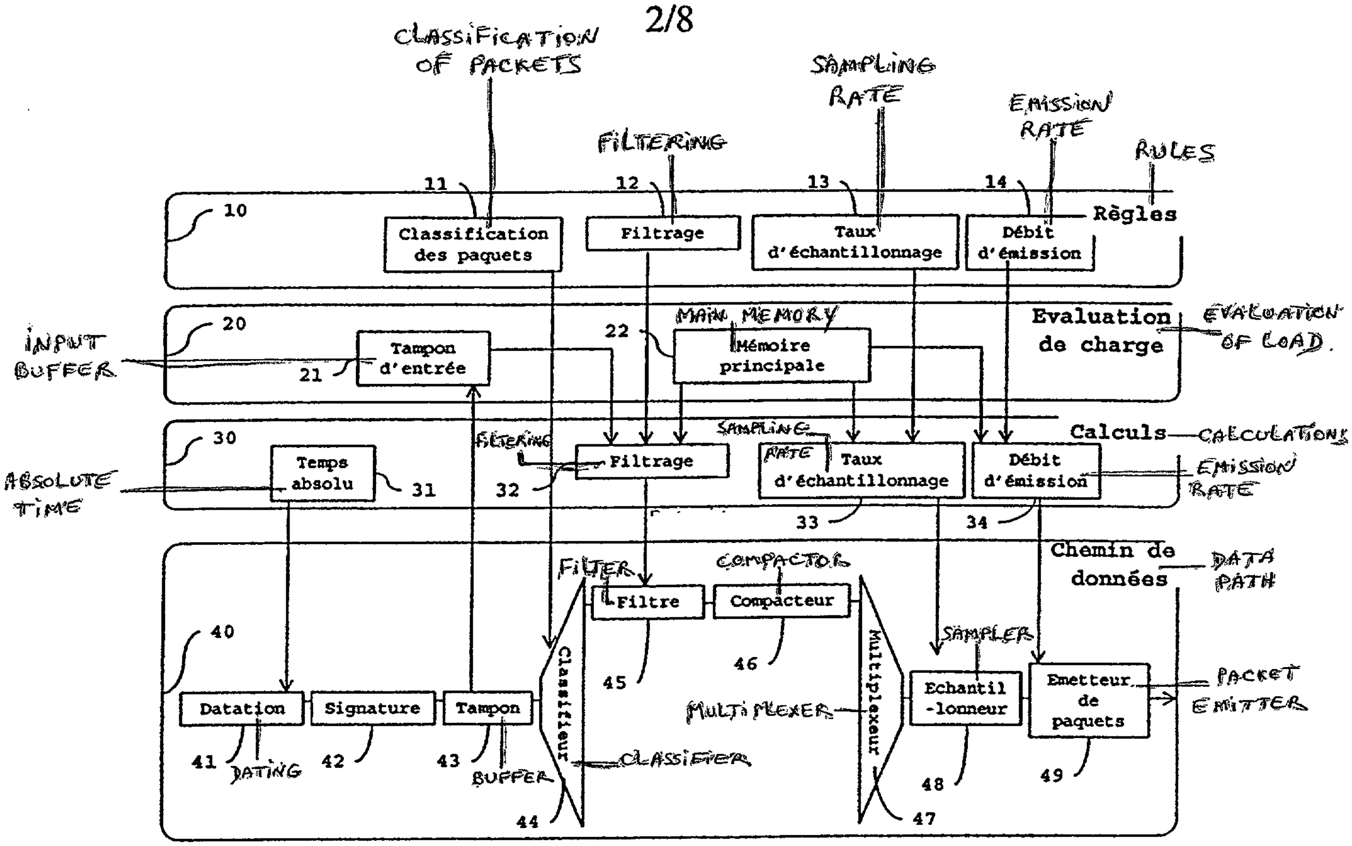

CLASSIFICATION OF PACKETS
SAMPLING RATE
EMISSION RATE
FILTERING
RULES
11
12
13
14
10
Classification des paquets
Filtrage
Taux d'échantillonnage
Débit d'émission
Règles
20
MAIN MEMORY
Evaluation de charge
EVALUATION OF LOAD.
INPUT BUFFER
Tampon d'entrée
21
22
Mémoire principale
30
Calculs
CALCULATIONS
FILTERING
SAMPLING RATE
Temps absolu
ABSOLUTE TIME
31
32
Filtrage
Taux d'échantillonnage
Débit d'émission
EMISSION RATE
33
34
Chemin de données
DATA PATH
FILTER
COMPACTOR
Filtre
Compacteur
40
SAMPLER
45
46
Classifieur
Multiplexeur
MULTIPLEXER
Echantil -lonneur
Emetteur de paquets
PACKET EMITTER
Datation
Signature
Tampon
41
DATING
42
43
BUFFER
CLASSIFIER
48
49
44
47

FIG 3

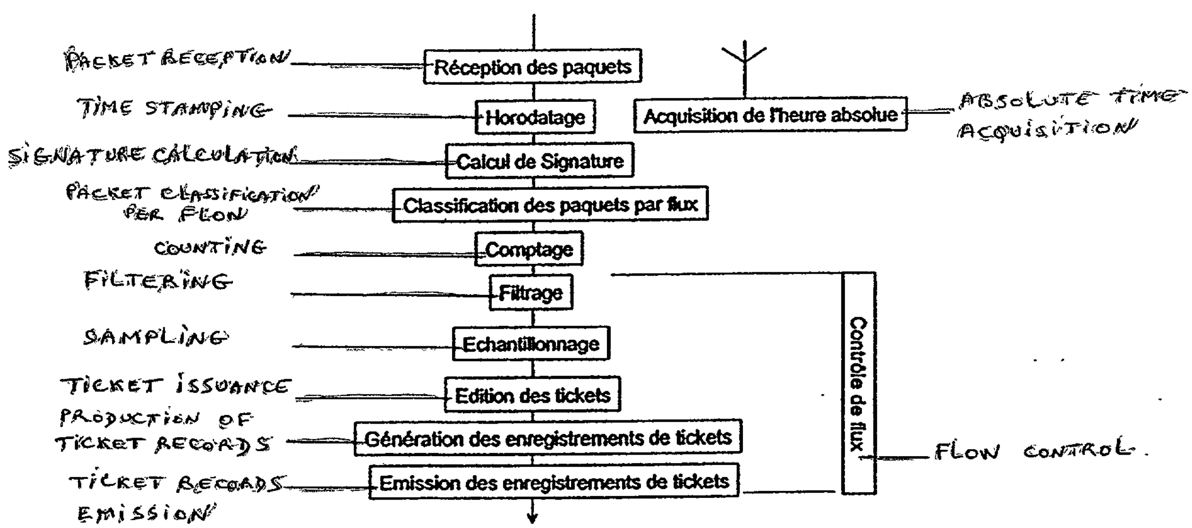
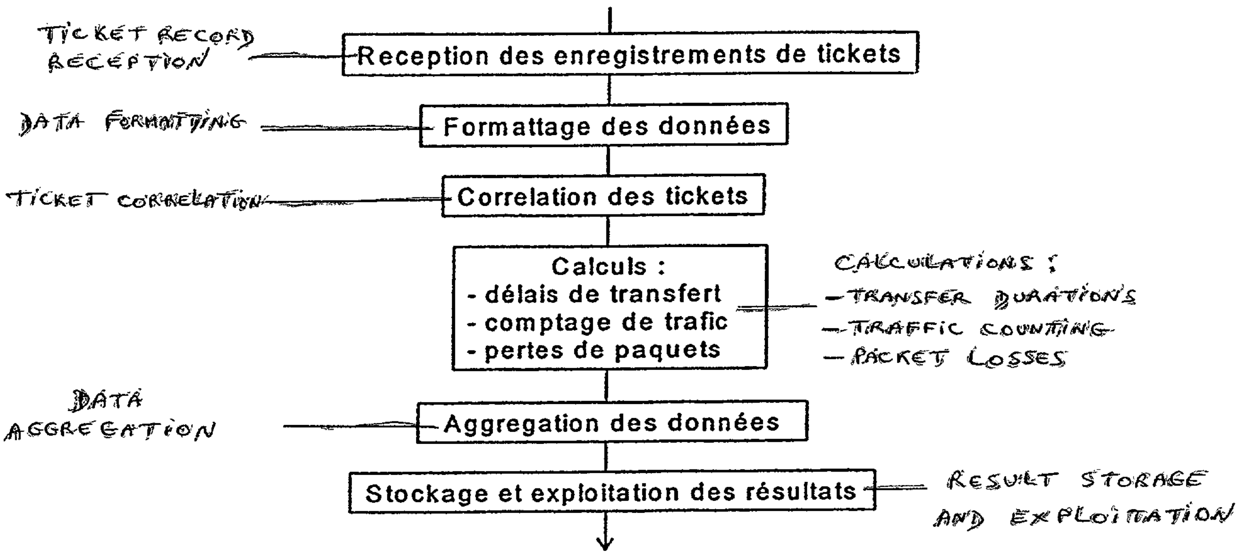
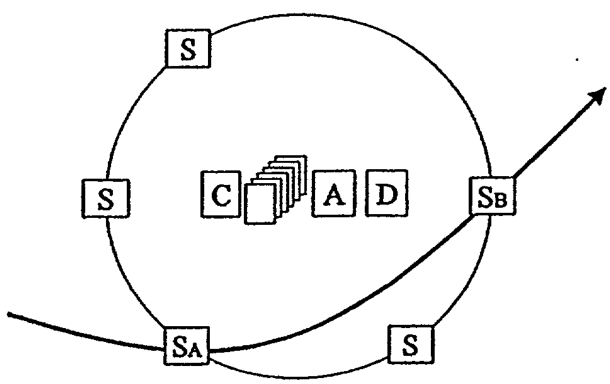

PACKET RECEPTION
Réception des paquets
TIME STAMPING
Horodatage
Acquisition de l'heure absolue
ABSOLUTE TIME ACQUISITION
SIGNATURE CALCULATION
Calcul de Signature
PACKET CLASSIFICATION PER FLOW
Classification des paquets par flux
COUNTING
Comptage
FILTERING
Filtrage
SAMPLING
Echantillonnage
TICKET ISSUANCE
Edition des tickets
PRODUCTION OF TICKET RECORDS
Génération des enregistrements de tickets
TICKET RECORDS EMISSION
Emission des enregistrements de tickets
Contrôle de flux
FLOW CONTROL.

FIG 4



TICKET RECORD RECEPTION
Reception des enregistrements de tickets
DATA FORMATTING
Formattage des données
TICKET CORRELATION
Correlation des tickets
Calculs :
- délais de transfert
- comptage de trafic
- pertes de paquets
CALCULATIONS :
-TRANSFER DURATIONS
-TRAFFIC COUNTING
-PACKET LOSSES
DATA AGGREGATION
Aggregation des données
Stockage et exploitation des résultats
RESULT STORAGE AND EXPLOITATION

FIG 5



S
S
C
A
D
SB
SA
S

FIG 6

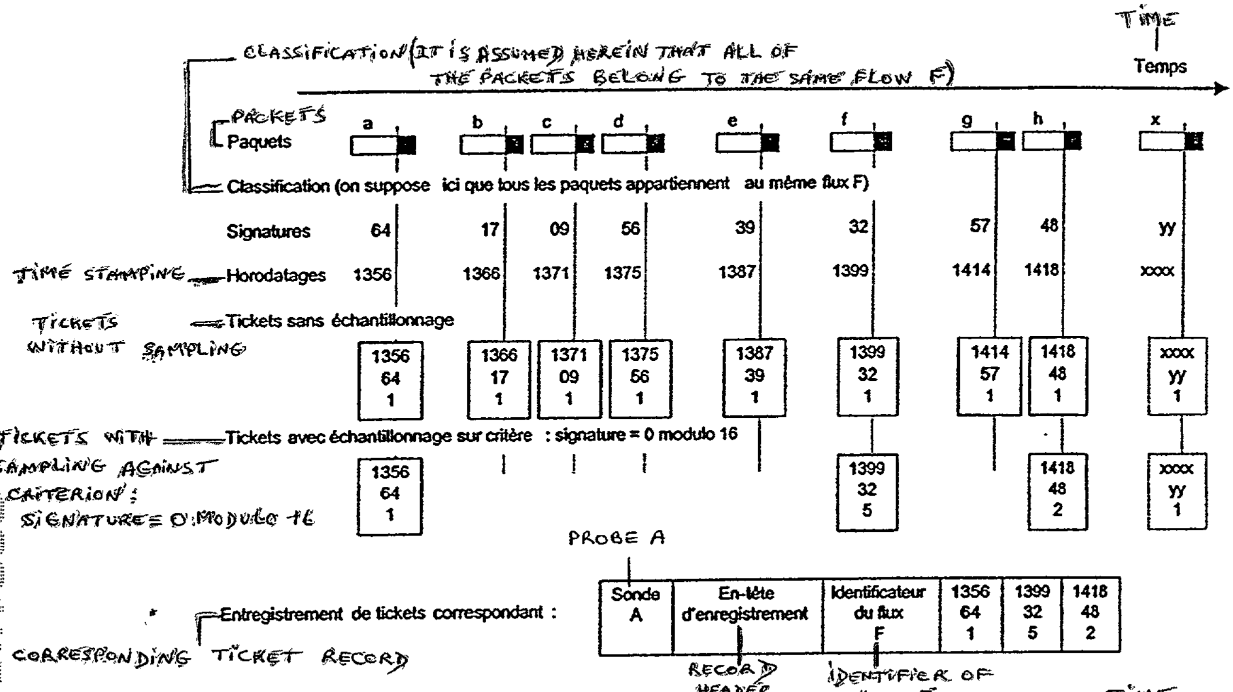

TIME
Temps
CLASSIFICATION (IT IS ASSUMED HEREIN THAT ALL OF THE PACKETS BELONG TO THE SAME FLOW F)
PACKETS
Paquets
a b c d e f g h x
Classification (on suppose ici que tous les paquets appartiennent au même flux F)
Signatures 64 17 09 56 39 32 57 48 yy
TIME STAMPING
Horodatages 1356 1366 1371 1375 1387 1399 1414 1418 xxxx
TICKETS WITHOUT SAMPLING
Tickets sans échantillonnage
1356 64 1
1366 17 1
1371 09 1
1375 56 1
1387 39 1
1399 32 1
1414 57 1
1418 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION: SIGNATURE = 0 MODULO 16
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1356 64 1
1399 32 5
1418 48 2
xxxx yy 1
PROBE A
Entregistrement de tickets correspondant :
CORRESPONDING TICKET RECORD
Sonde A
En-tête d'enregistrement
Identificateur du flux F
1356 64 1
1399 32 5
1418 48 2
RECORD HEADER
IDENTIFIER OF FLOW F

FIG 7

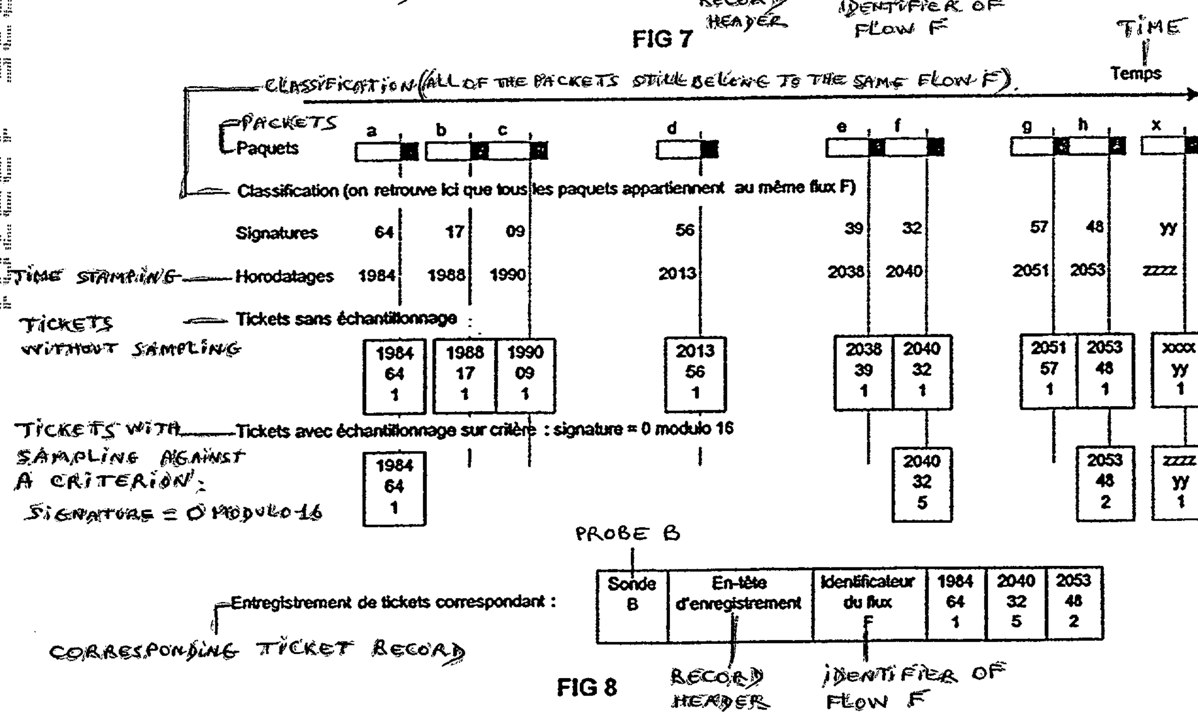

TIME
Temps
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
PACKETS
Paquets
a b c d e f g h x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures 64 17 09 56 39 32 57 48 yy
TIME STAMPING
Horodatages 1984 1988 1990 2013 2038 2040 2051 2053 zzzz
TICKETS WITHOUT SAMPLING
Tickets sans échantillonnage :
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2040 32 1
2051 57 1
2053 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION: SIGNATURE = 0 MODULO 16
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1984 64 1
2040 32 5
2053 48 2
zzzz yy 1
PROBE B
Entregistrement de tickets correspondant :
CORRESPONDING TICKET RECORD
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2040 32 5
2053 48 2
RECORD HEADER
IDENTIFIER OF FLOW F

FIG 8

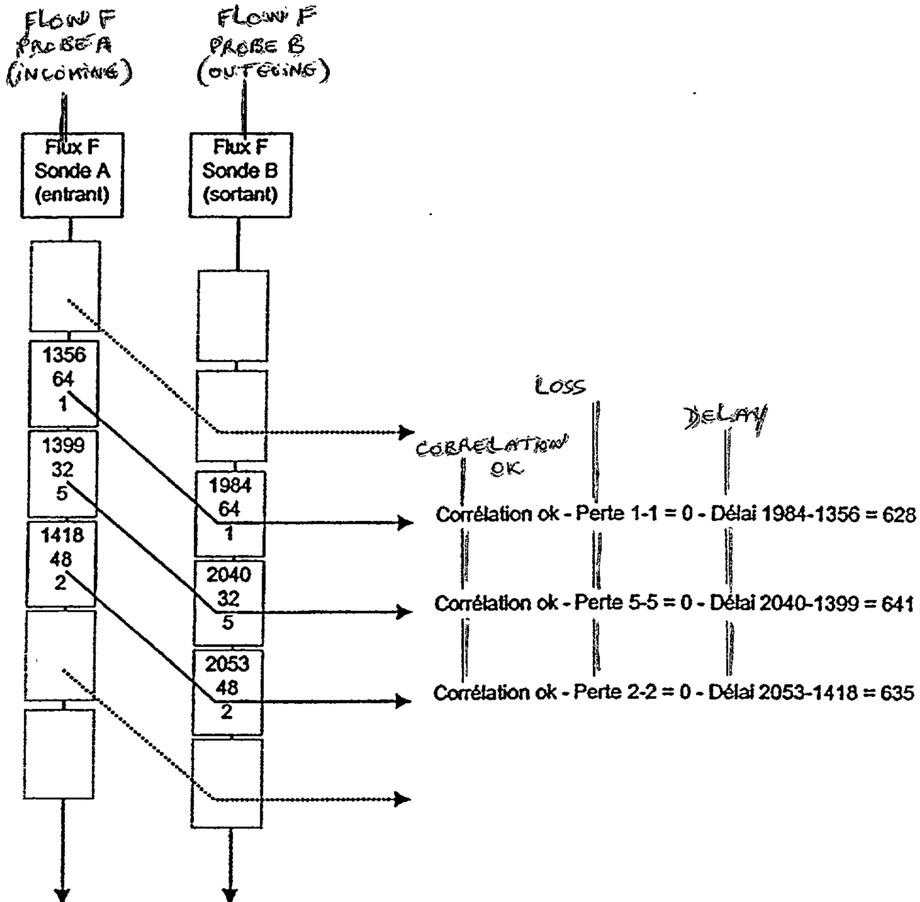

FLOW F
PROBE A
(INCOMING)
FLOW F
PROBE B
(OUTGOING)
Flux F
Sonde A
(entrant)
Flux F
Sonde B
(sortant)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2040
32
5
2053
48
2
LOSS
DELAY
CORRELATION OK
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte 5-5 = 0 - Délai 2040-1399 = 641
Corrélation ok - Perte 2-2 = 0 - Délai 2053-1418 = 635

FIG 9

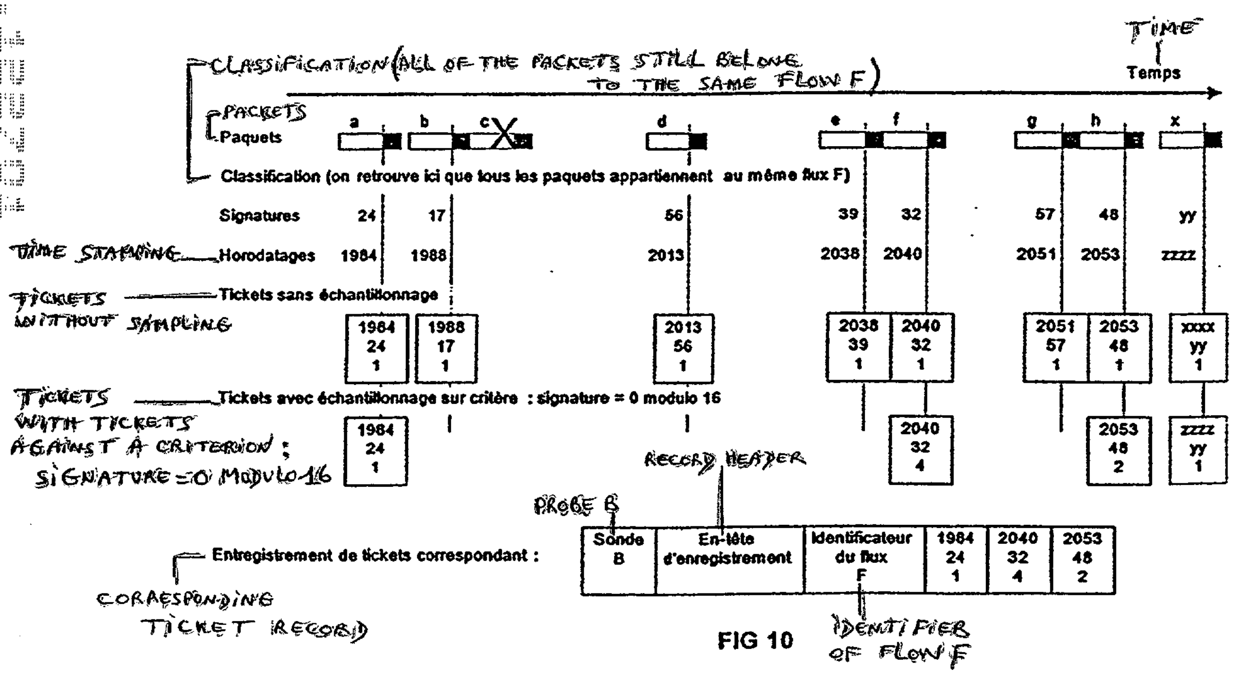
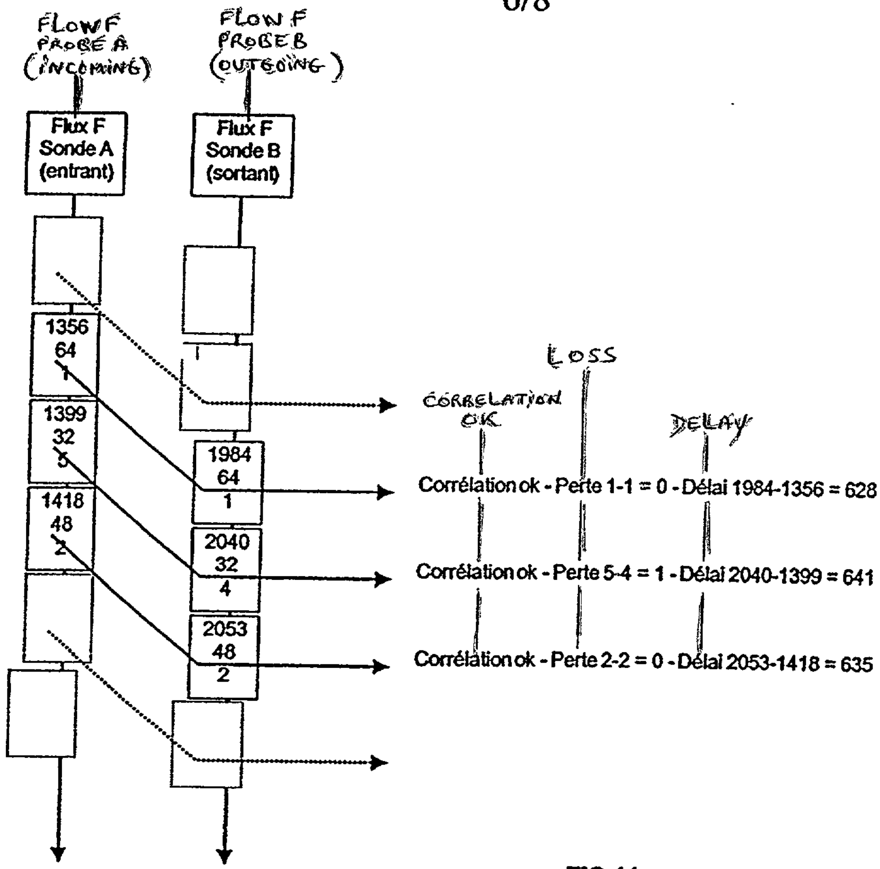
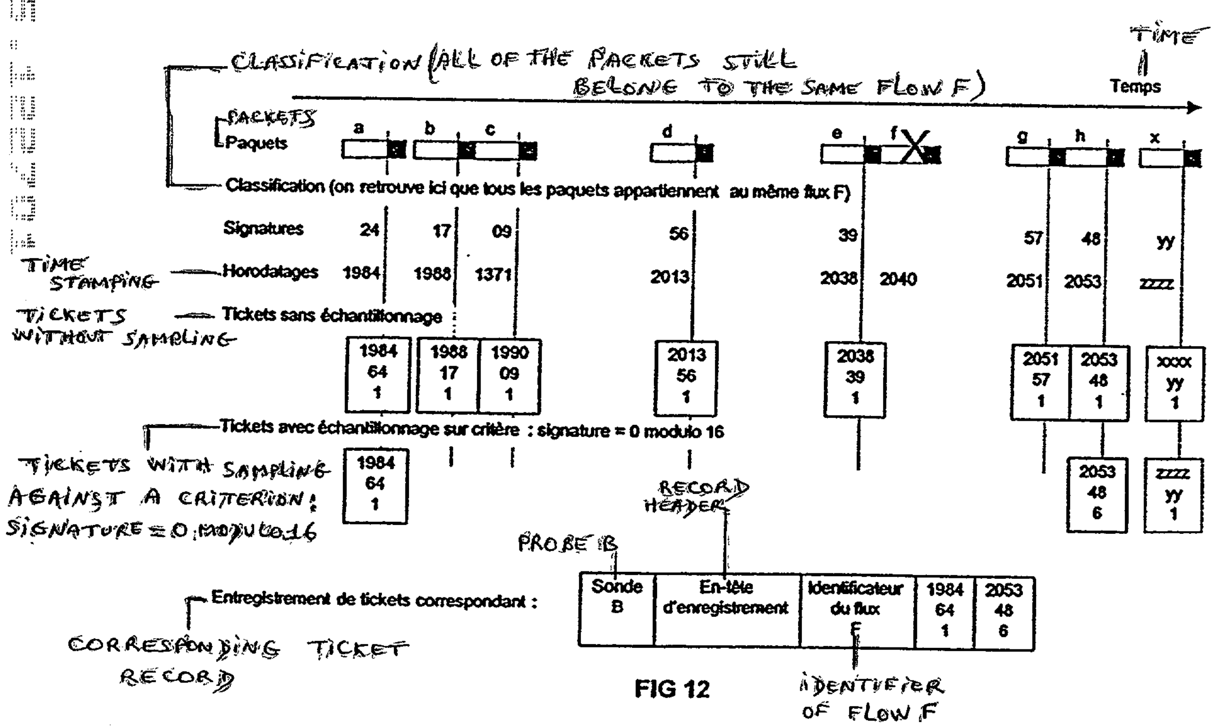

TIME
Temps
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
PACKETS
Paquets
a
b
c
d
e
f
g
h
x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures
24
17
56
39
32
57
48
yy
TIME STAMPING
Horodatages
1984
1988
2013
2038
2040
2051
2053
zzzz
TICKETS WITHOUT SAMPLING
Tickets sans échantillonnage
1984 24 1
1988 17 1
2013 56 1
2038 39 1
2040 32 1
2051 57 1
2053 48 1
xxxx yy 1
TICKETS WITH TICKETS AGAINST A CRITERION ; SIGNATURE = 0 MODULO 16
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1984 24 1
2040 32 4
2053 48 2
zzzz yy 1
RECORD HEADER
PROBE B
Entregistrement de tickets correspondant :
CORRESPONDING TICKET RECORD
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 24 1
2040 32 4
2053 48 2
IDENTIFIER OF FLOW F

FIG 10



FLOW F PROBE A (INCOMING)
FLOW F PROBE B (OUTGOING)
Flux F Sonde A (entrant)
Flux F Sonde B (sortant)
1356 64 1
1399 32 5
1418 48 2
1984 64 1
2040 32 4
2053 48 2
CORRELATION OK
LOSS
DELAY
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte 5-4 = 1 - Délai 2040-1399 = 641
Corrélation ok - Perte 2-2 = 0 - Délai 2053-1418 = 635

FIG 11



CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
TIME
Temps
PACKETS
Paquets
a b c d e f g h x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures 24 17 09 56 39 57 48 yy
TIME STAMPING
Horodatages 1984 1988 1371 2013 2038 2040 2051 2053 zzzz
TICKETS WITHOUT SAMPLING
Tickets sans échantillonnage
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2051 57 1
2053 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
TICKETS WITH SAMPLING AGAINST A CRITERION: SIGNATURE = 0 MODULO 16
1984 64 1
2053 48 6
zzzz yy 1
RECORD HEADER
PROBE B
Entregistrement de tickets correspondant :
CORRESPONDING TICKET RECORD
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2053 48 6
IDENTIFIER OF FLOW F

FIG 12

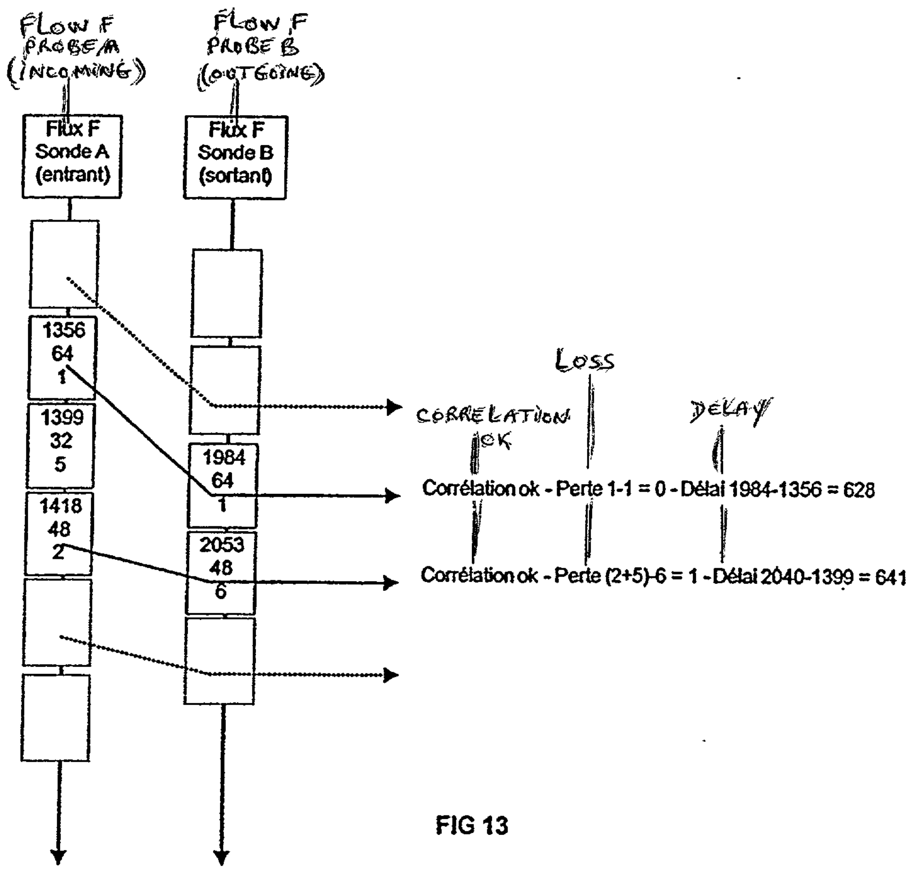

FLOW F PROBE A (INCOMING)
FLOW F PROBE B (OUTGOING)
Flux F Sonde A (entrant)
Flux F Sonde B (sortant)
1356 64 1
1399 32 5
1418 48 2
1984 64 1
2053 48 6
LOSS
CORRELATION OK
DELAY
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte (2+5)-6 = 1 - Délai 2040-1399 = 641

FIG 13

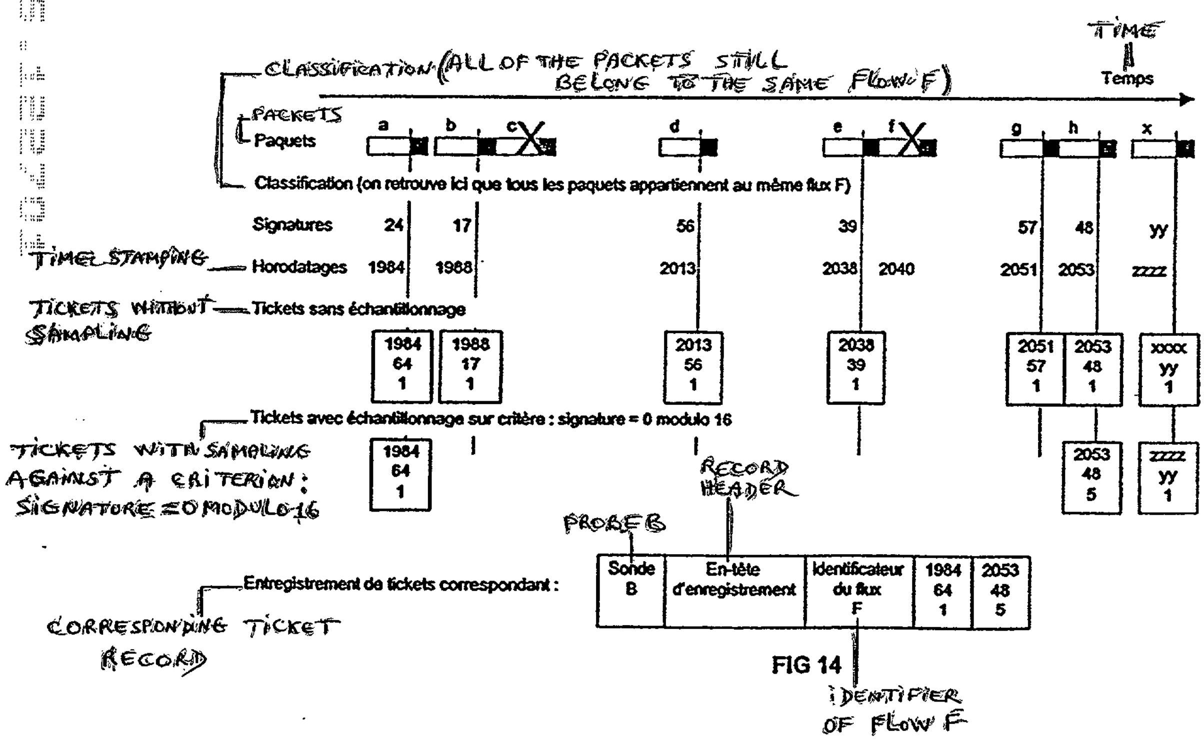

CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
TIME
Temps
PACKETS
Paquets
a b c d e f g h x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures 24 17 56 39 57 48 yy
TIME STAMPING
Horodatages 1984 1988 2013 2038 2040 2051 2053 zzzz
TICKETS WITHOUT SAMPLING
Tickets sans échantillonnage
1984 64 1
1988 17 1
2013 56 1
2038 39 1
2051 57 1
2053 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
TICKETS WITH SAMPLING AGAINST A CRITERION: SIGNATURE = 0 MODULO 16
1984 64 1
2053 48 5
zzzz yy 1
RECORD HEADER
PROBE B
Entregistrement de tickets correspondant :
CORRESPONDING TICKET RECORD
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2053 48 5
IDENTIFIER OF FLOW F

FIG 14

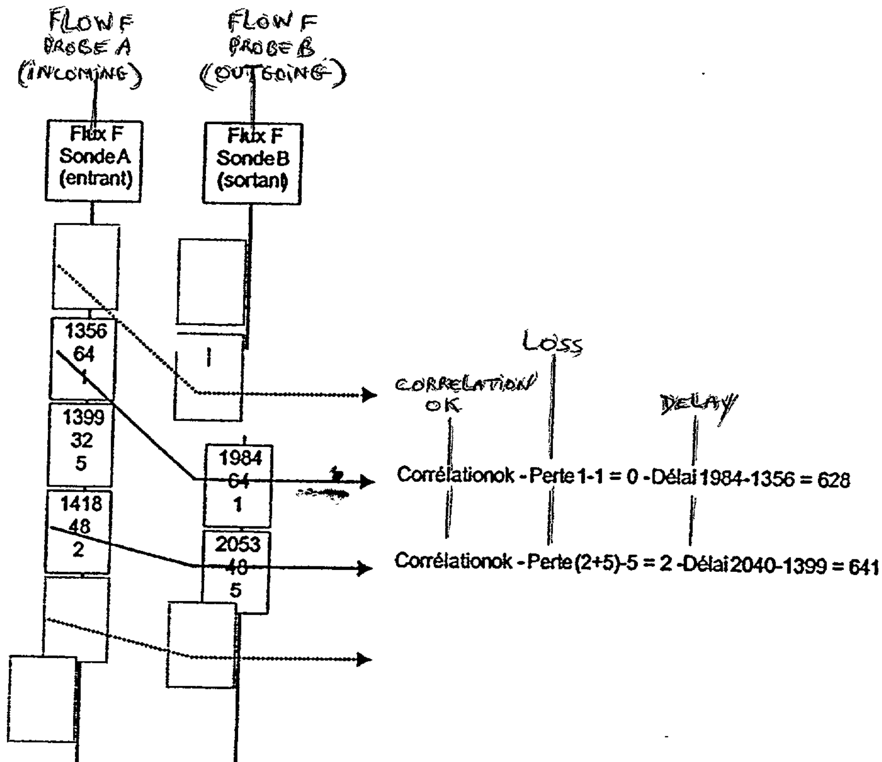

FLOW F PROBE A (INCOMING)
FLOW F PROBE B (OUTGOING)
Flux F Sonde A (entrant)
Flux F Sonde B (sortant)
1356 64 1
1399 32 5
1418 48 2
1984 64 1
2053 48 5
CORRELATION OK
LOSS
DELAY
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte (2+5)-5 = 2 - Délai 2040-1399 = 641

FIG 15

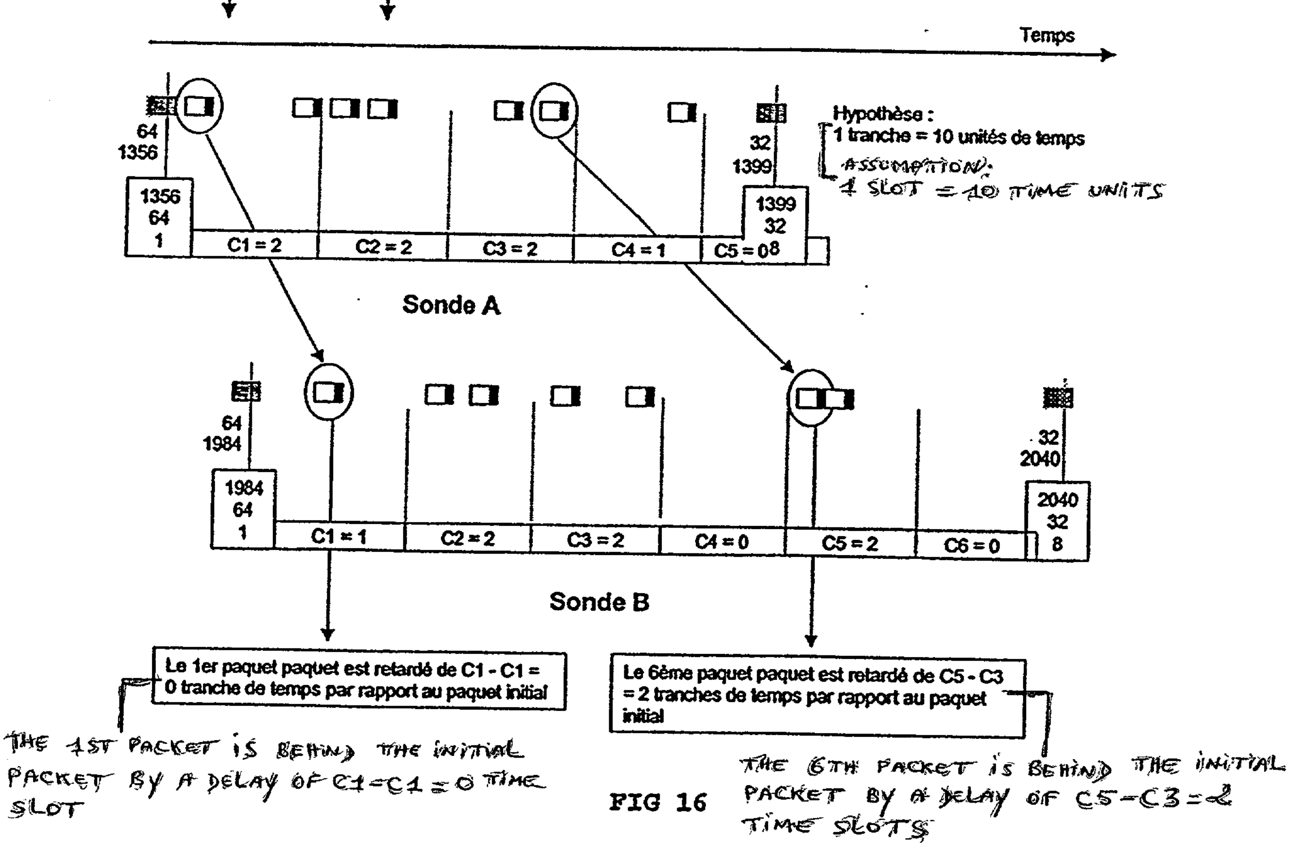

Temps
64 1356
1356 64 1
C1 = 2
C2 = 2
C3 = 2
C4 = 1
C5 = 08
32 1399
1399 32
Hypothèse :
1 tranche = 10 unités de temps
ASSUMPTION:
1 SLOT = 10 TIME UNITS
Sonde A
64 1984
1984 64 1
C1 = 1
C2 = 2
C3 = 2
C4 = 0
C5 = 2
C6 = 0
32 2040
2040 32 8
Sonde B
Le 1er paquet paquet est retardé de C1 - C1 = 0 tranche de temps par rapport au paquet initial
Le 6ème paquet paquet est retardé de C5 - C3 = 2 tranches de temps par rapport au paquet initial
THE 1ST PACKET IS BEHIND THE INITIAL PACKET BY A DELAY OF C1-C1 = 0 TIME SLOT
THE 6TH PACKET IS BEHIND THE INITIAL PACKET BY A DELAY OF C5-C3 = 2 TIME SLOTS

FIG 16

#4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : THIERRY GRENOT Docket No.: 01-515

Serial No. : 09/914,335 Examiner :

Filed : Art Unit :

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For : SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS

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Dear Sir:

Applicant submits herewith eight (8) sheets of formal drawings for the above-identified U.S. patent application.

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Antoinette Sullo
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Date: November 30, 2001

Respectfully submitted,

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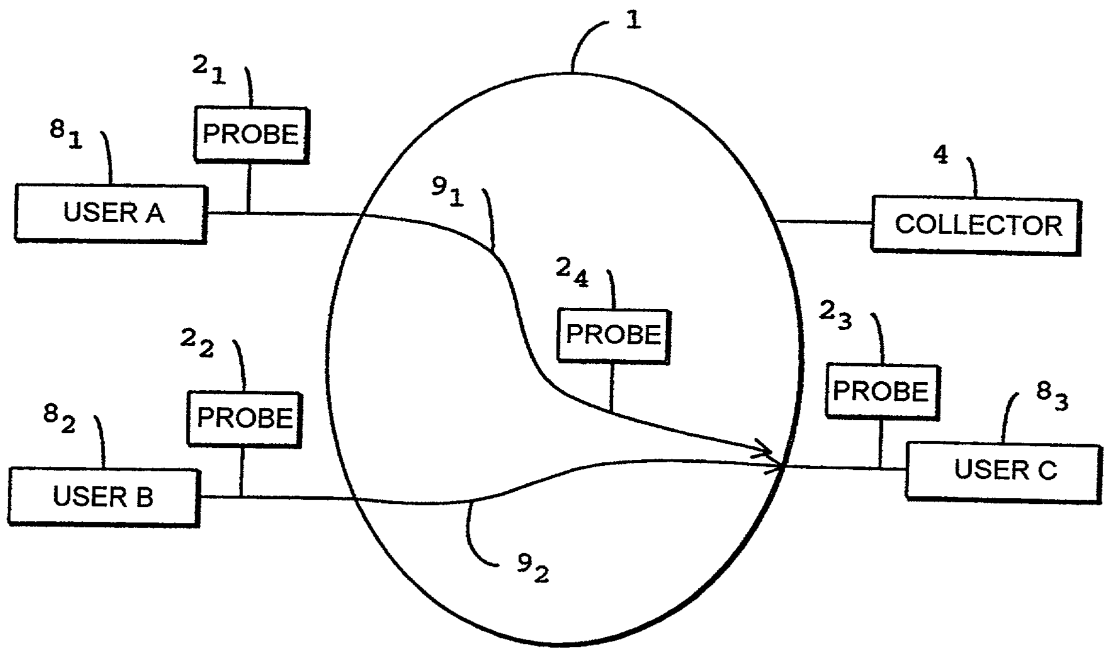

1
2_1
PROBE
8_1
USER A
9_1
4
COLLECTOR
2_4
PROBE
2_3
PROBE
8_3
USER C
2_2
PROBE
8_2
USER B
9_2

FIG1

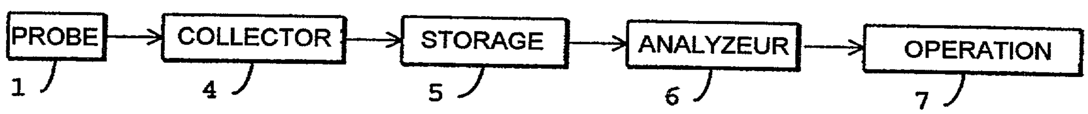
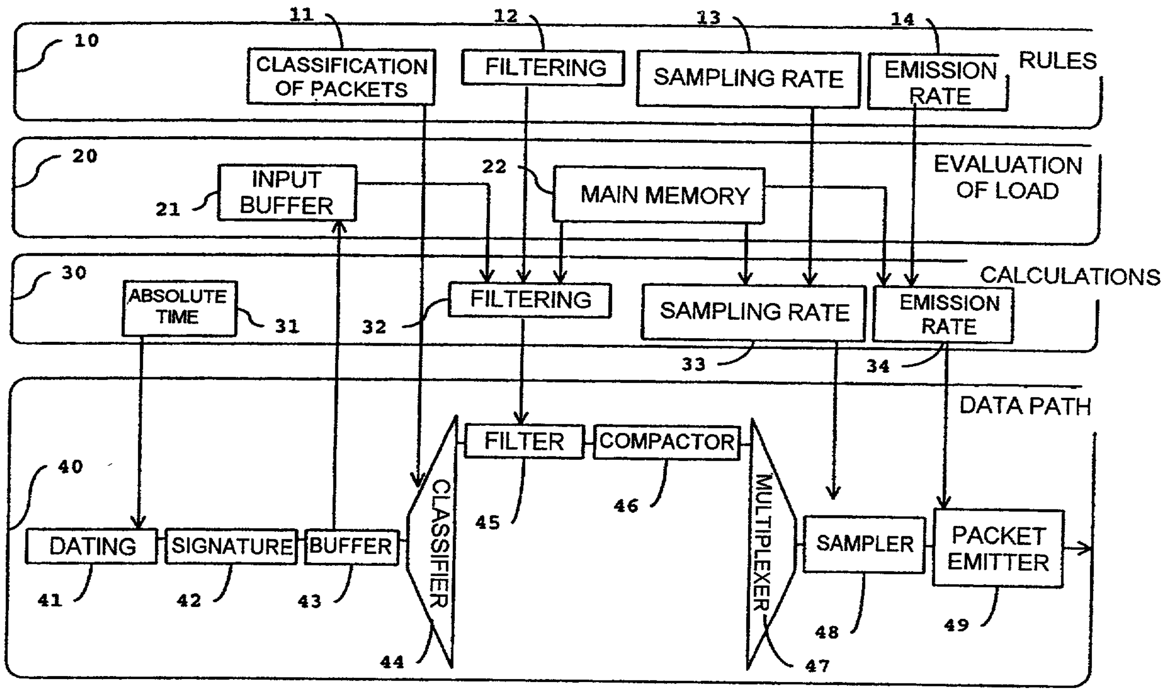
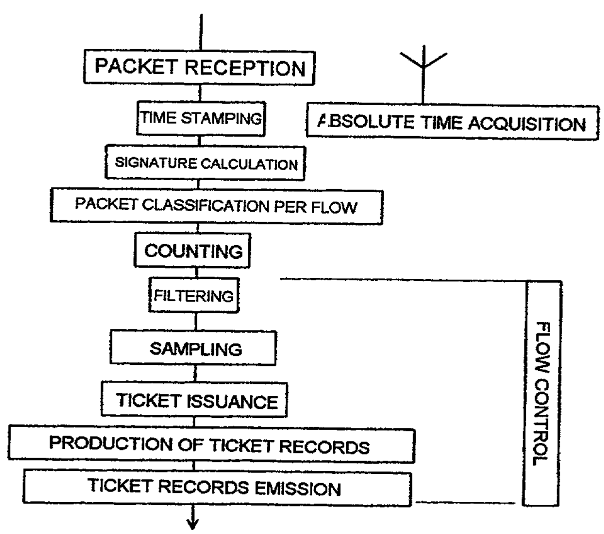

PROBE
1
COLLECTOR
4
STORAGE
5
ANALYZEUR
6
OPERATION
7

FIG 2



RULES
10
11
CLASSIFICATION OF PACKETS
12
FILTERING
13
SAMPLING RATE
14
EMISSION RATE
EVALUATION OF LOAD
20
21
INPUT BUFFER
22
MAIN MEMORY
CALCULATIONS
30
ABSOLUTE TIME
31
32
FILTERING
SAMPLING RATE
33
EMISSION RATE
34
DATA PATH
40
DATING
41
SIGNATURE
42
BUFFER
43
CLASSIFIER
44
FILTER
45
COMPACTOR
46
MULTIPLEXER
47
SAMPLER
48
PACKET EMITTER
49

FIG 3



PACKET RECEPTION
TIME STAMPING
ABSOLUTE TIME ACQUISITION
SIGNATURE CALCULATION
PACKET CLASSIFICATION PER FLOW
COUNTING
FILTERING
SAMPLING
TICKET ISSUANCE
PRODUCTION OF TICKET RECORDS
TICKET RECORDS EMISSION
FLOW CONTROL

FIG 4

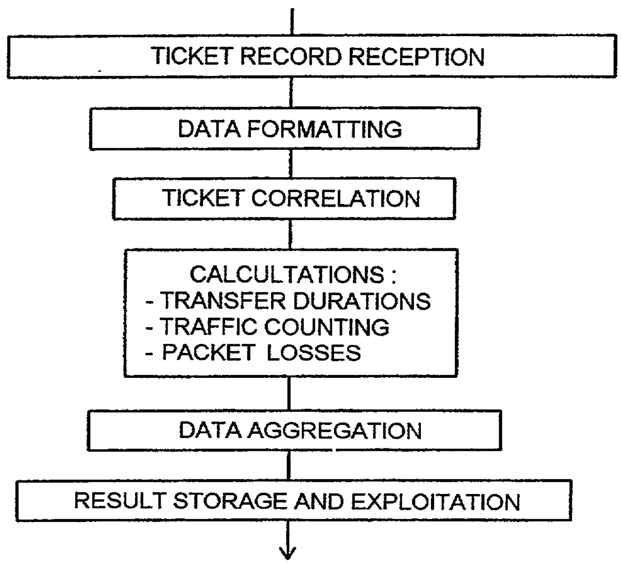

TICKET RECORD RECEPTION
DATA FORMATTING
TICKET CORRELATION
CALCULTATIONS :
- TRANSFER DURATIONS
- TRAFFIC COUNTING
- PACKET LOSSES
DATA AGGREGATION
RESULT STORAGE AND EXPLOITATION

FIG 5

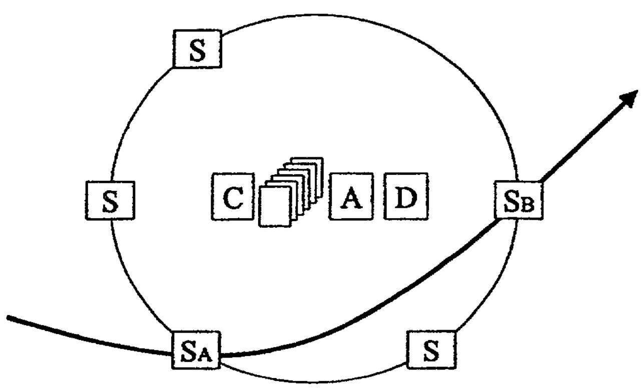

S
S
C
A
D
SB
SA
S

FIG 6

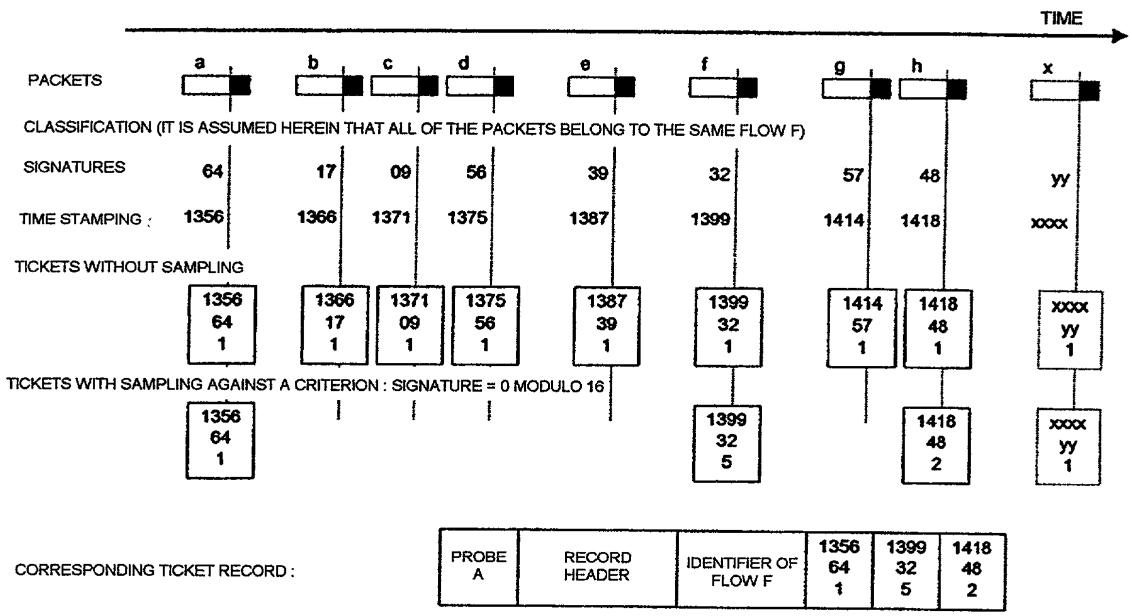

TIME
PACKETS
a
b
c
d
e
f
g
h
x
CLASSIFICATION (IT IS ASSUMED HEREIN THAT ALL OF THE PACKETS BELONG TO THE SAME FLOW F)
SIGNATURES
64
17
09
56
39
32
57
48
yy
TIME STAMPING :
1356
1366
1371
1375
1387
1399
1414
1418
xxxx
TICKETS WITHOUT SAMPLING
1356 64 1
1366 17 1
1371 09 1
1375 56 1
1387 39 1
1399 32 1
1414 57 1
1418 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION : SIGNATURE = 0 MODULO 16
1356 64 1
1399 32 5
1418 48 2
xxxx yy 1
CORRESPONDING TICKET RECORD :
PROBE A
RECORD HEADER
IDENTIFIER OF FLOW F
1356 64 1
1399 32 5
1418 48 2

FIG 7

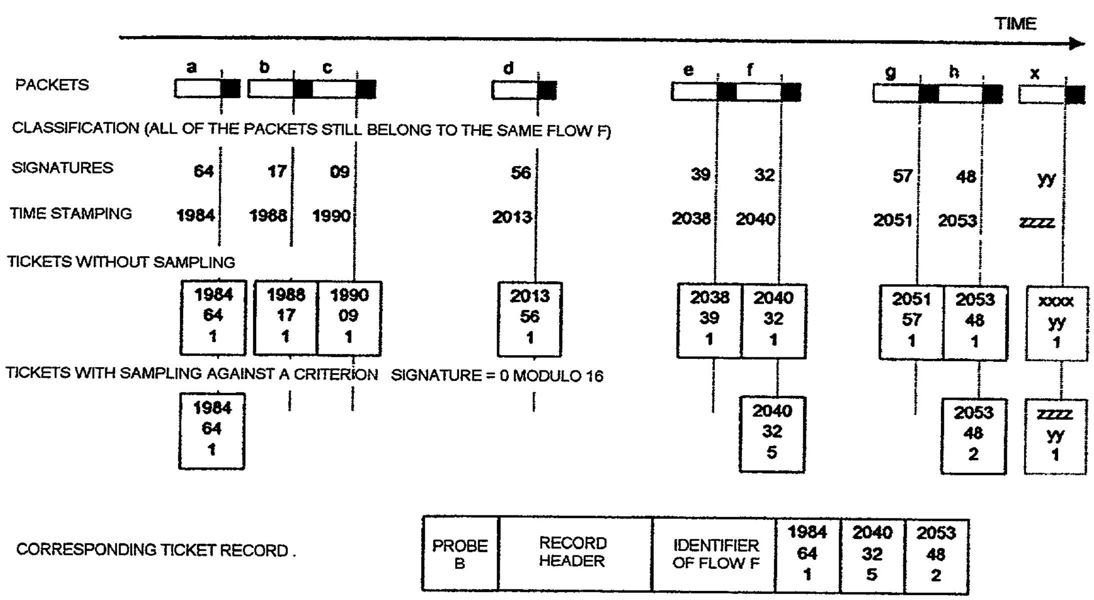

TIME
PACKETS
a
b
c
d
e
f
g
h
x
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
SIGNATURES
64
17
09
56
39
32
57
48
yy
TIME STAMPING
1984
1988
1990
2013
2038
2040
2051
2053
zzzz
TICKETS WITHOUT SAMPLING
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2040 32 1
2051 57 1
2053 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION SIGNATURE = 0 MODULO 16
1984 64 1
2040 32 5
2053 48 2
zzzz yy 1
CORRESPONDING TICKET RECORD .
PROBE B
RECORD HEADER
IDENTIFIER OF FLOW F
1984 64 1
2040 32 5
2053 48 2

FIG 8

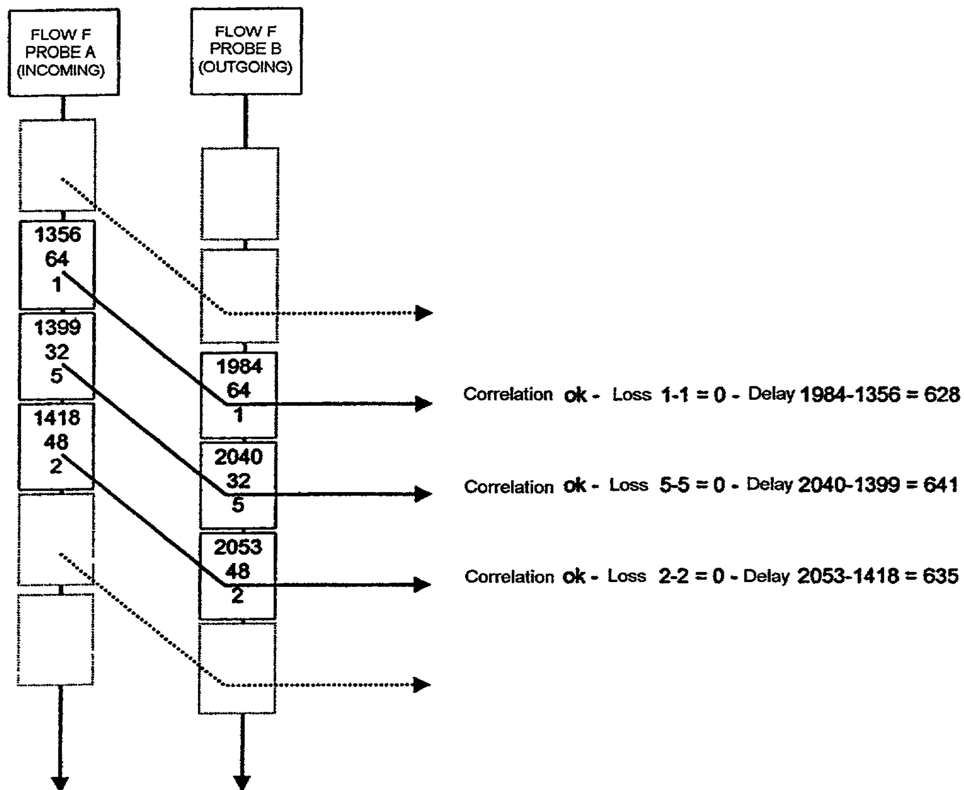

FLOW F
PROBE A
(INCOMING)
FLOW F
PROBE B
(OUTGOING)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2040
32
5
2053
48
2
Correlation ok - Loss 1-1 = 0 - Delay 1984-1356 = 628
Correlation ok - Loss 5-5 = 0 - Delay 2040-1399 = 641
Correlation ok - Loss 2-2 = 0 - Delay 2053-1418 = 635

FIG 9

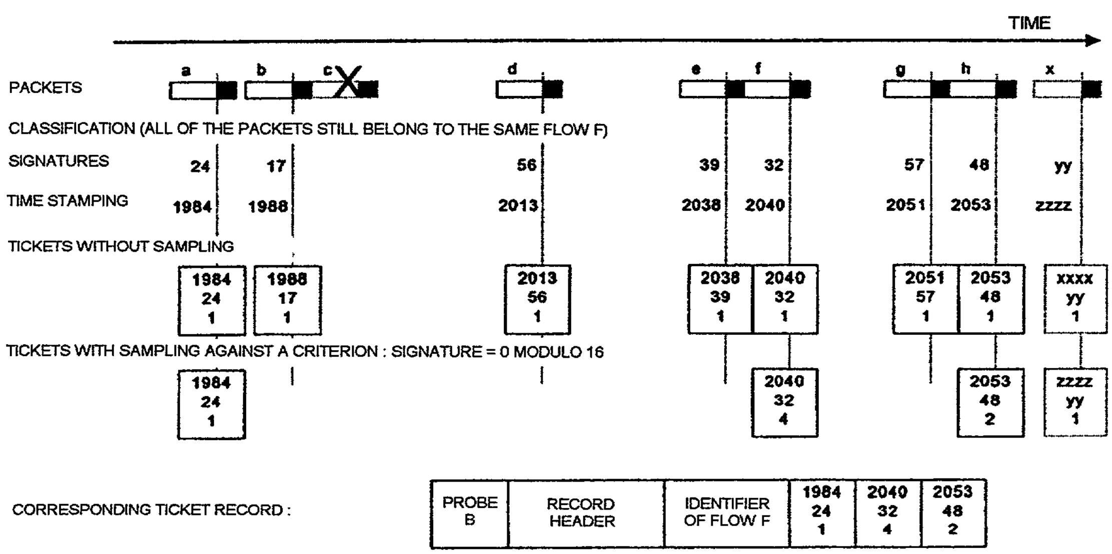

TIME
PACKETS
a
b
c
d
e
f
g
h
x
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
SIGNATURES
24
17
56
39
32
57
48
yy
TIME STAMPING
1984
1988
2013
2038
2040
2051
2053
zzzz
TICKETS WITHOUT SAMPLING
1984 24 1
1988 17 1
2013 56 1
2038 39 1
2040 32 1
2051 57 1
2053 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION : SIGNATURE = 0 MODULO 16
1984 24 1
2040 32 4
2053 48 2
zzzz yy 1
CORRESPONDING TICKET RECORD :
PROBE B
RECORD HEADER
IDENTIFIER OF FLOW F
1984 24 1
2040 32 4
2053 48 2

FIG 10

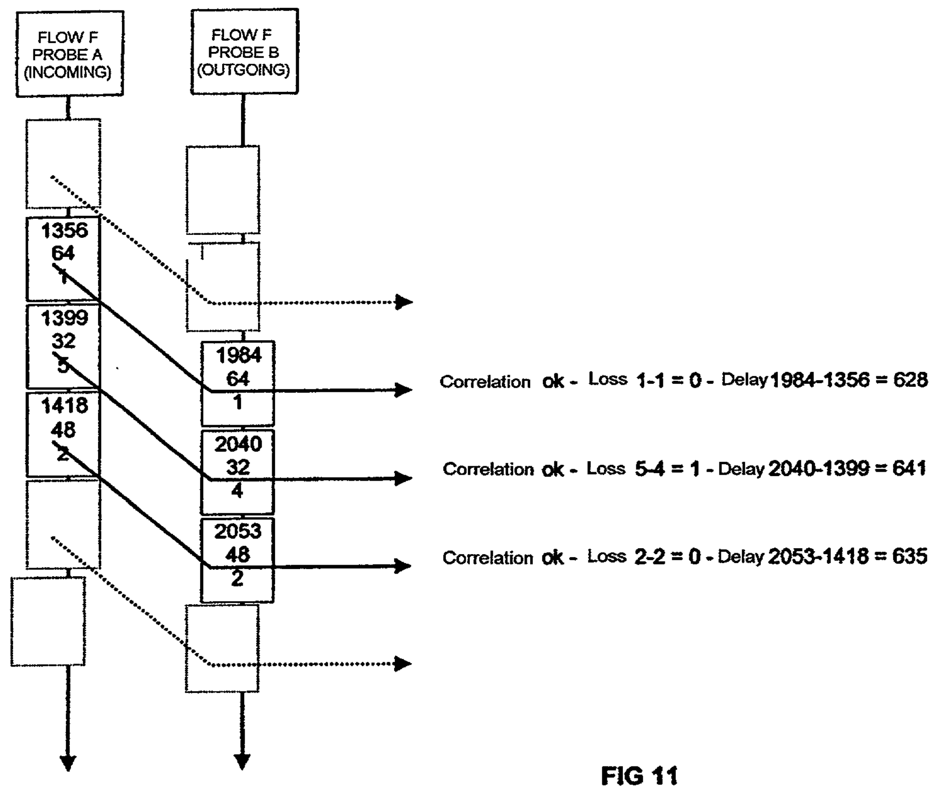

FLOW F
PROBE A
(INCOMING)
FLOW F
PROBE B
(OUTGOING)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2040
32
4
2053
48
2
Correlation ok - Loss 1-1 = 0 - Delay 1984-1356 = 628
Correlation ok - Loss 5-4 = 1 - Delay 2040-1399 = 641
Correlation ok - Loss 2-2 = 0 - Delay 2053-1418 = 635

FIG 11

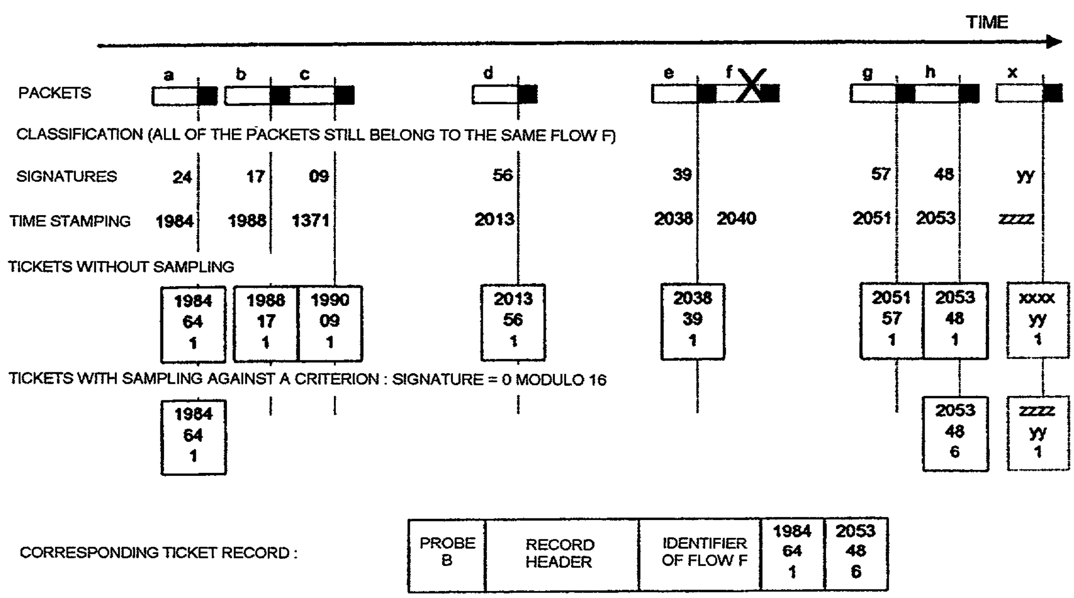

TIME
PACKETS
a b c d e f g h x
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
SIGNATURES 24 17 09 56 39 57 48 yy
TIME STAMPING 1984 1988 1371 2013 2038 2040 2051 2053 zzzz
TICKETS WITHOUT SAMPLING
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2051 57 1
2053 48 1
xxxx yy 1
TICKETS WITH SAMPLING AGAINST A CRITERION : SIGNATURE = 0 MODULO 16
1984 64 1
2053 48 6
zzzz yy 1
CORRESPONDING TICKET RECORD :
PROBE B
RECORD HEADER
IDENTIFIER OF FLOW F
1984 64 1
2053 48 6

FIG 12

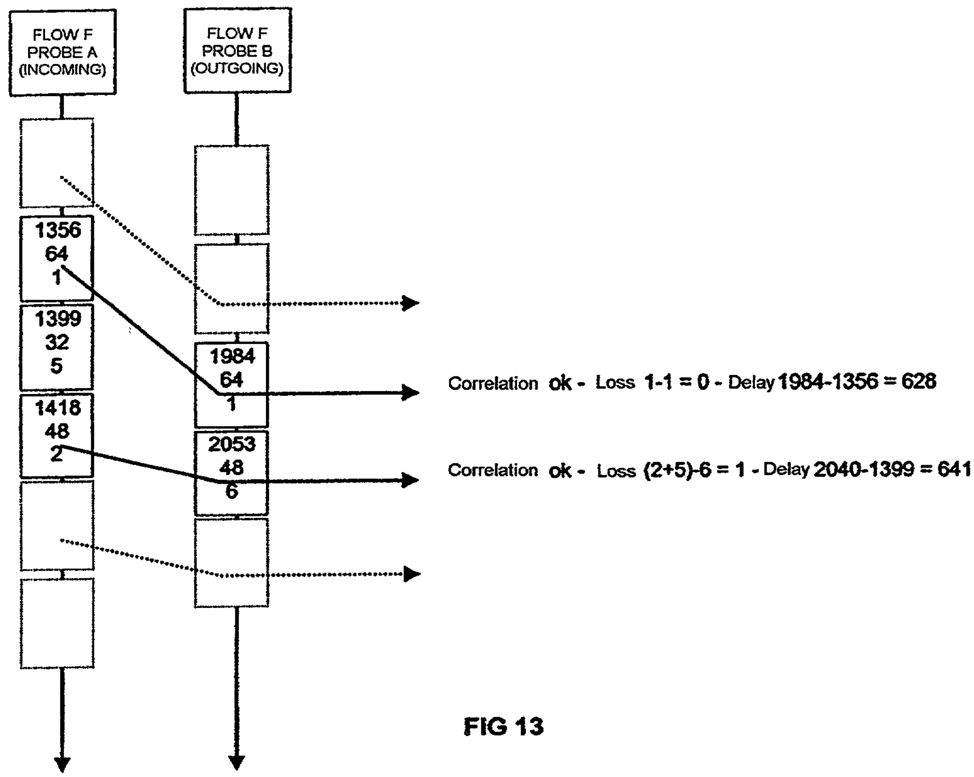

FLOW F
PROBE A
(INCOMING)
FLOW F
PROBE B
(OUTGOING)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2053
48
6
Correlation ok - Loss 1-1 = 0 - Delay 1984-1356 = 628
Correlation ok - Loss (2+5)-6 = 1 - Delay 2040-1399 = 641

FIG 13

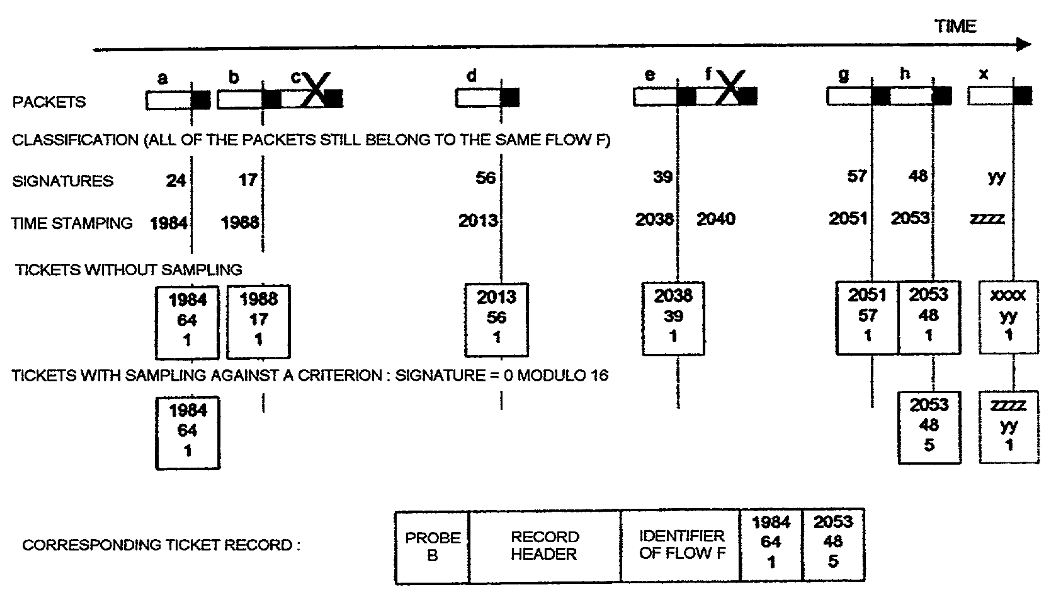

TIME
a
b
c
d
e
f
g
h
x
PACKETS
CLASSIFICATION (ALL OF THE PACKETS STILL BELONG TO THE SAME FLOW F)
SIGNATURES 24 17 56 39 57 48 yy
TIME STAMPING 1984 1988 2013 2038 2040 2051 2053 zzzz
TICKETS WITHOUT SAMPLING
1984
64
1
1988
17
1
2013
56
1
2038
39
1
2051
57
1
2053
48
1
xxxx
yy
1
TICKETS WITH SAMPLING AGAINST A CRITERION : SIGNATURE = 0 MODULO 16
1984
64
1
2053
48
5
zzzz
yy
1
CORRESPONDING TICKET RECORD :
PROBE
B
RECORD
HEADER
IDENTIFIER
OF FLOW F
1984
64
1
2053
48
5

FIG 14

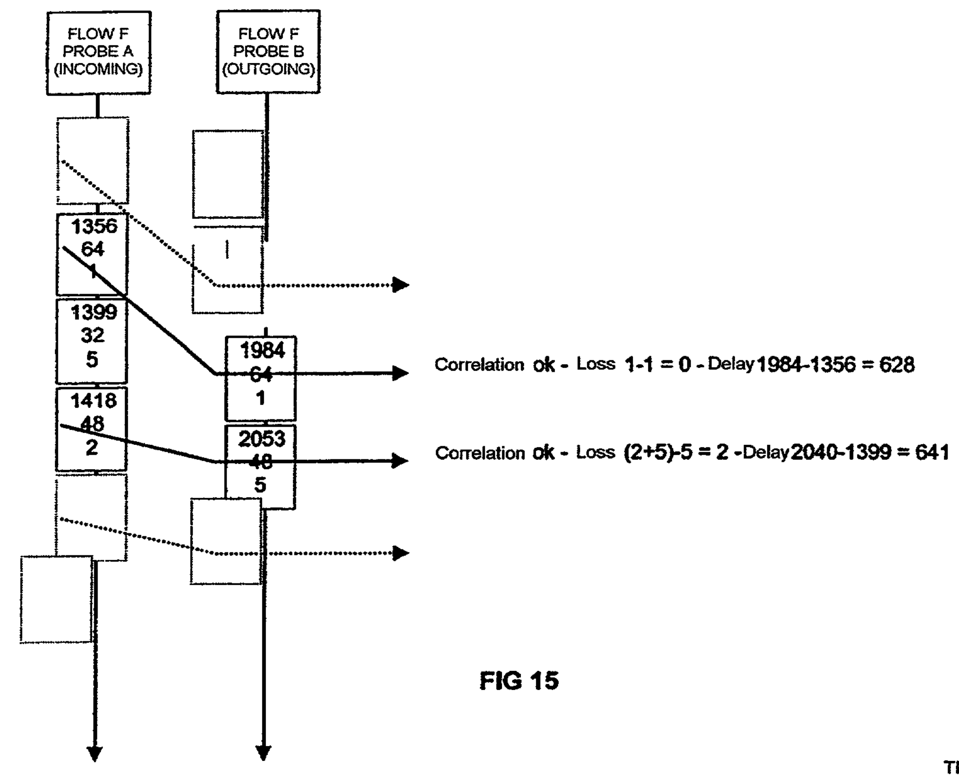

FLOW F
PROBE A
(INCOMING)
FLOW F
PROBE B
(OUTGOING)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2053
48
5
Correlation ok - Loss 1-1 = 0 - Delay 1984-1356 = 628
Correlation ok - Loss (2+5)-5 = 2 -Delay 2040-1399 = 641

FIG 15

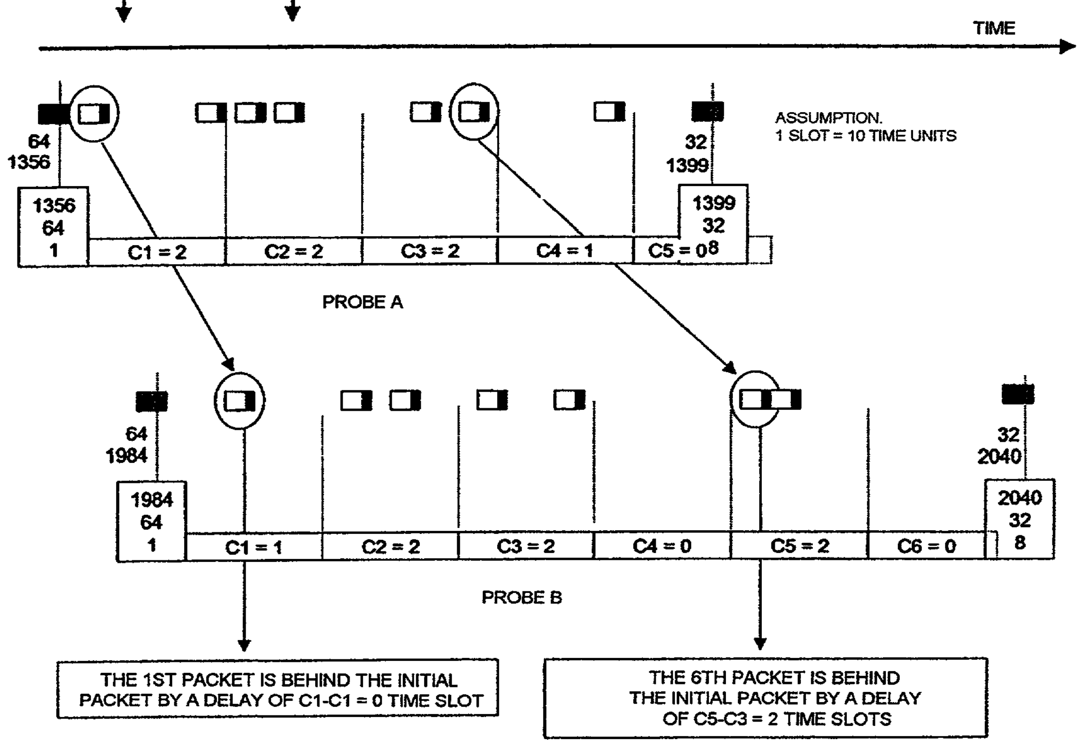

TIME
64
1356
32
1399
ASSUMPTION.
1 SLOT = 10 TIME UNITS
1356
64
1
C1 = 2
C2 = 2
C3 = 2
C4 = 1
C5 = 0
1399
32
8
PROBE A
64
1984
32
2040
1984
64
1
C1 = 1
C2 = 2
C3 = 2
C4 = 0
C5 = 2
C6 = 0
2040
32
8
PROBE B
THE 1ST PACKET IS BEHIND THE INITIAL
PACKET BY A DELAY OF C1-C1 = 0 TIME SLOT
THE 6TH PACKET IS BEHIND
THE INITIAL PACKET BY A DELAY
OF C5-C3 = 2 TIME SLOTS

FIG 16

8/prts
09/914335
JC03 Rec'd PCT/PTO 24 AUG 2001

SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS

The present invention relates to a non-intrusive method for measuring the loss rates and transfer durations for data in a telecommunication network in packet mode.

The invention is particularly adapted to high volume networks that are operated in non-connected mode. It relates also to a *distributed architecture* system comprising a plurality of flow observation probes arranged in several points in the network, and means for transmitting these measurements to a collecting module which is connected to storage means and means for analyzing the measurements that have been provided.

Packet mode telecommunication networks are characterized in that transmitted information are conveyed in groups referred to as packets, that are substantially made up of one header which contains information for sending a packet through the network as well as data to be transmitted. Such packets are conveyed through the network, and travel, in accordance to what suits the best the latter, through the most diversified transmitting and switching means.

An exemplary packet mode network is the Internet network which is operated with IP protocol (Internet Protocol). As a few examples of transmitting and switching means related to the IP protocol, ISDN (integrated services digital network), FR (Frame Relay), ATM (Asynchronous Transfer Mode), SDH (Synchronous Digital Hierarchy), SONET (Synchronous Optical network), DWDM (Dense Wavelength Digital Multiplexing) networks, etc., can be found.

Packets are typically transmitted from a large number of sources operating independently with one another, towards a large number of recipients that operate independently with one another as well.

Since the transmission timing of packets and the length of every packet are not accurately defined by the network itself, it is difficult for the network operator and users to guarantee and even estimate the transfer duration and the loss rate (likelihood that one packet will not reach the intended destination). Therefore, it would be very useful to carry out accurate measurements on real data pertaining to useful packets, so that administration, configuration, and planning of a packet mode network can be made possible. Good knowledge of these characteristics would facilitate equally the implementation of services with differentiated and guaranteed quality, as opposed to a best effort type service.

One conventional solution to achieve such a result is to make use of one or more sources that send test packets, referred to as "ping" in an IP network. Each test packet is recognized by its recipient and is sent back by the latter to the corresponding source. This source is able then to carry out measurements, such as the round-trip transmission duration. Statistical processing is also possible based on measurements performed on a large number of packets ; for instance, to estimate the characteristics of the round-trip transfer durations (maximum, minimum, mean, median, etc…).

Another solution that is used consists in providing part of sources and recipients with a sufficiently accurate knowledge of a common time reference. Sources produce test packets and take notice of the starting time. Recipients take notice of the reception time for these test packets. Then,

calculations are carried out as to characterize, for example, the transfer durations and loss rates.

However, with the above-mentioned solutions it is not possible to achieve a good accuracy on every occasion. Actually, the number of test packets has to remain small for neither overloading the network, nor using too many devices. Hence, statistical estimates might carry a high degree of inaccuracy. Besides this, packet mode networks often do not feature identical characteristics on the way out and the way back paths, between two access points. Moreover, the devices for the packet mode network (such as routers and switchers) analyze frequently the packet contents (for example, the transport protocol from end to end, the data type, the type of file which is contained in the packet, etc...), in order to infer therefrom a process for transmitting the packet, the queue, or the priority, etc... Consequently, test packets might not follow the same path as do the packets which contain real data for network users. This results in a high degree of uncertainty about the measurement of transfer duration of packets containing real data for network users.

From the U.S. Patent n° 5,521,907, another solution is also known, which permits measurement in a non-intrusive way between two points in a known network. However, that solution is strictly limited to networks in connected mode, such as frame relay, and therefore, cannot be used in non-connected mode networks, nor high volume networks. Further, with that method, analysis of packet losses is not possible.

Moreover, from the U.S. Patent n° 5,535,193, a solution which permits determination of the passage time of the packets by a plurality of synchronized network analyzers. However, this solution makes use of a separate connection for controlling the synchronization, and requires thus the analyzers to be

close with one another.

The present invention aims to alleviate the above-mentioned drawbacks.

To this end, one object of the invention is to provide a method and a system with a distributed architecture that allow to measure accurately the transfer durations and loss rates for telecommunication networks in packet mode. The method comprises the steps for performing the measurement operations by a plurality of observing probes that are synchronized and distributed at different points in the network, on data packets which are transmitted through the network, the measurement operations comprising the dating and the identification of the data packets, the measurement results being transmitted from the probes to the collecting module.

The method according to the invention is characterized in that the measurement operations further comprise a classification of the data packets in a homogenous flow, and a counting of the packets in the flow, the measurement results being transmitted from the probes to the collecting module through the network (1), the collecting module performing a correlation between all of the measurement results received from the probes, including the determination of the unidirectional transfer durations per flow or information flow group, and of the loss rate for the packets.

The method according to the invention is advantageous in that it does not require the use of test packets, which permits the achievement of a very wide representativeness of every measurement. It is also advantageous in that a large number of measurements can be carried out, resulting in a high degree of statistical accuracy. Finally, the number of measurements being carried out can be modulated in

accordance with the types of data conveyed within the packets, authorizing a rational use of the resources which are available in the system.

Besides this, classification of the data packets in a homogenous flow makes possible :

- to refine the measurement (per destination, per application type, …) ;
- to index the reference space for signatures, to minimize thereby double signature likelihood, and to ease incoming flow/outgoing flow correlations.

Another advantage offered by the classification of the data packets in a homogenous flow is that a signature with a small length can be kept while having a low probability of ambiguity resulting from similar signatures appended to different packets. This is effective to ease strongly the system operation on the wide network.

In practice, the flow is determined from the network addresses (which define the paths), the transport addresses and the optional elements that enable the network to select the service quality to be applied. Alternatives are possible, for example, to bring together IP addresses into sub-network corresponding to a single destination. In the case where an Internet network is used, source and destination IP addresses could be selected, as well as, either the ToS (type of service) field, or the TCP/UDP source and destination ports. Other clusters may be employed without departing from the scope of the invention.

The counting of the packet in the flow is used to determine packet losses in the network. The size of the counter depends of the implementation, nevertheless remaining at a reasonable level by using the fact related to a given flow. Ongoing

implementations can be satisfactorily achieved with counters having a 8-32 bits width.

The method according to the invention enables equally an accurate measurement of the losses of packets in the network, operating such a network with numerous points giving access to the observed area, while maintaining a simplified structure. It is also applicable to point-to-multipoint flows.

Advantageously, the signature which identifies the packet shows the three following characteristics :

- it is kept in the network, at any measurement point. When determining it, this will result in ignoring fields that correspond to the physical layers and the network layers having a level lower than the layer at which operates the system ;
- its length is small compared to the mean length of the packets. This allows to limit the amount of information to supply the collector with ;
- the likelihood that two different packets have the same signature for a given flow is low. This allows to limit the number of disabled measurements.

According to another important characteristic of the invention, the method comprises a filtering step and a semi-static sampling step for classes obtained during the classification step.

In this case, only a part of the packet combinations belonging to a given class will be retained. The sampling rate depends typically of the class, and will not theoretically change dynamically. For instance, it may be desirable to keep all of the combinations of packets conveying voice, and only a part of those that convey computer files.

Further, each class can be submitted to a dynamic sampling with a rate which depends of the congestion conditions in the system.

A multiplicity of criteria may be used so that the overall operation could take place automatically in an area that suits the best the device administrator, for instance, with the highest sampling rate for a given maximum network flow rate, or a minimum network flow rate for a given sampling rate.

With the sampling mechanism, the method according to the invention enables an observation of extremely high volume networks and a diminution of flows brought back from the probes to the collector as well as a dynamic optimization of the measurement characteristics, which authorizes an adaptive optimization in accordance with the operating conditions of the system.

According to an important characteristic of the invention, the measurement of the transfer durations and the counting of the packet are synchronized as a function of an absolute time reference gained by the measuring probes that are distributed through the network.

With the absolute time reference, it is possible to obtain loss rates and transfer durations in each communication direction. For example, according to the accuracy and the cost which are required, the absolute time reference can be gained through GPS devices, radio broadcasting, network protocols.

Noting the absolute time of the passage of the packet (time stamping) will be used to calculate transfer durations between two probes. For instance, in the case where an Internet network is used, an accuracy of about 100 µs may be selected.

The system for implementing the method according to the invention is characterized in that each probe further comprises means for classifying the data packets in a homogenous flow, means for identifying each packet, means for counting the packets

in one flow, the transmitting means of the probes using the network to transmit the measurements carried out to the collecting module, the collecting module comprising means for determining the unidirectional transfer durations per flow or information flow group and the loss rate for the packets.

Other characteristics and advantages of the invention will be more fully understood from the following description to be considered as a non-limitative example while referring to the appended drawings, in which :

- Figure 1 shows schematically an exemplary embodiment of the invention in a telecommunication network in packet mode ;
- Figure 2 shows a functional diagram of a system implementing a method according to the invention;
- Figure 3 depicts schematically an example of an internal functional organization for a system according to the invention ;
- Figure 4 shows a functional diagram depicting the operation of an observing probe used in a system according to the invention ;
- Figure 5 shows a functional diagram depicting the operation of a collecting module used in a system according to the invention ;
- Figures 6 to 15 depict schematically the operation of a system according to the invention.

In Fig. 1, there is shown schematically a high volume network 1 that is operated in non-connected mode, such as a network based on IP protocol (Internet Protocol). A plurality of flow-observing probes 2_i are arranged at different points in the network for carrying out measurements on flows of data that are exchanged through this network. Means for compressing

these measurements are provided in probes 2_i as well as means for transmitting them to a collecting module 4. The latter acts to collect and correlate the elementary measurements that were carried out by the observing probes 2_i.

As it can be seen from Fig. 2, said collecting module 4 is connected to storage means 5 that communicate with means 6 for analyzing measurements that were performed. Thereafter, results of these analyses are sent to an operating module 7. Those different modules may be, either dissociated physically, or partially or entirely provided in one or more common physical equipment.

The method according to the invention is characterized substantially by :

- a step for classifying the data packets in a homogenous flow ;
- a step for calculating an identification signature for each packet ;
- a step for counting the packets in the flow ;
- a step for measuring the unidirectional transfer durations per flow or information flow group and the loss rate for the packets.

Respective order of these steps may be changed according to the different requirements put on when implementing.

As it is depicted in Fig. 1, users 8_1, 8_2 and 8_3 are connected to the network 1. Observing probes 2_1 and 2_4 have access to packets 9_1 originated from 8_1, the probe 2_2 has access to packets originated from 8_2, the probe 2_3 has access to packets received by 8_3. The collecting module 4 is connected to the network 1 and behaves as a user of this network 1, communicating through this network with the probes 2_1, 2_2, 2_3, and 2_4, which are users of the network 1 as well. These probes 2_1, 2_2, 2_3, and 2_4 carry out measurement operations for

each packet they have access to. These measurements consist in performing dating, classification and identification of the packets, as well as compressing these measurements. Every probe 2_i transmits, through the network 1, the compressed measurements to the collecting module 4 that correlates all of these measurements.

Other embodiments are also possible in the scope of the present invention, notably in the following cases :

- the users 8_i are not necessarily end users for information being conveyed within the packets ; for instance, they may represent local networks or other networks in packet mode ;
- the probes 2i can be connected to the collecting module 4 through means other than the network 1; for instance, through another telecommunication network, or through a local storage medium that stores data from the collecting module 4, sending them back to it later on ;
- the same collecting module 4 can be connected to several collecting modules 4 ;
- several collecting modules 4 can communicate to build up correlations between measurement elements they have.

As an example, a possible functional diagram of the system according to the invention is shown in Fig. 3. Four functional groups can be found therein :

- the rule group 10, with the rules being fixed statically or semi-statically (for example by the system operator);
- the load evaluation group 20, measuring the load rate on the local central processing unit, the memory occupancy, etc… ;
- the calculation group 30, evaluating dynamically the values relating to compaction, sampling, etc… ;

- the data path group 40, producing records that contain combinations (class, date, signature) for each packet.

When activated, the probes 2_i gain a common time reference 31. The inaccuracy of this reference between two probes 2_i affects directly the accuracy of the result for the whole device. Means for gaining that time reference can be diversified as well as multiple ; as non-limitative examples, GPS (Global Positioning System), broadcasting through radio waves, high stability drivers, NTP (Network Time Protocol) and SNTP (Simple Network Time Protocol) protocols may be mentioned ;

- each packet is subjected to dating 41 using the absolute time reference when it is observed by a probe 2i. The latter is able to date, either the start of the packet, or the end of the packet, or any other criterion.
- each packet is subjected to the calculation of the signature 42, that is for representing it later on. The signature enables to reduce the amount of information which is needed to identify the packet. That signature results typically from a binary polynomial calculation (for instance, CRC calculation - cyclic redundancy check - on 16 or 32 bit elements). The signature calculation is performed either on the whole packet or on a part of it, in accordance to what is contemplated in relation with the structure and the variability of the contents of the packets in the network. The signature has to be small compared to the mean packet size, so as to ease its storage, its transmission and its subsequent processing. It must be capable of assuming different values to make negligible the likelihood that two different packets have the same signature. As an example, it

can be considered that one signature on 16 bit elements enables to identify about 256 different packets with a low likelihood of ambiguity ;

- each packet is subjected to a classification operation 44. Criteria for classification are typically those that are conventionally retained to identify flows between networks and sub-networks (such as IP network sub-addresses), flows between end equipment (such as IP addresses), flows between applications (such as IP addresses and UDP/TCP transport addresses), etc… Each packet is then identified by combining all or part of the elements : class, date, signature;
- each class can be subjected to filtering 45 ; i.e., the probes 2i do not store the combinations (class, date, signature) for packets belonging to one of the classes for which the filter has been provided ;
- each class can be subjected to a compaction or a semi-static sampling operation 46. In this case, only a part of the combinations (class, date, signature) for packets belonging to a given class will be retained. The sampling rate depends typically of the class, and will not theoretically change dynamically. For instance, it may be desirable to keep all of the combinations of packets conveying voice, and only a part of those conveying computer files.
- each class can be subjected to a dynamic sampling with a rate which depends of the congestion conditions in the system : measurement of the occupancy of buffers 21 and memories 22 of the probes 2i, transmission flow rates towards the collecting module 4, network load, load of the collecting module 4, etc… A multiplicity of criteria can be used so that the overall operation

can take place automatically in an area that suits the best the device administrator. For instance, the highest sampling rate for a given maximum flow rate of a flow brought back from the probe to the collector, or a minimum flow rate of a flow brought back to the collector for a given sampling rate ;

- a counter is associated with each combination (class, date, signature) that is retained, indicating the number of packets observed in the flow. The collecting module 4 is then capable to measure the loss rate in the network by comparing between the counters associated with the same packets at different points in the network.

The filtering and static and dynamic sampling operations allow to reduce the amount of combinations (class, date, signature) to be stored et processed. The provision or removal of filters, the values of the semi-static sampling rates, the parameterization the dynamic sampling, etc…, can be achieved, for instance, through an administrative operation performed from one of the collecting modules 4 or operating modules 7.

Sampling criteria can be diversified. As examples, periodical sampling which consists in keeping one combination every N combinations, statistical sampling that depends on drawing a random variable of which statistical characteristics are under control, and sampling on signature that consists in keeping only those combinations of which the signatures belong to a given set of values can be mentioned.

The sequence order through which a probe 2_i performs the above-mentioned operations may change. A probe 2_i can classify the packets before dating them, as long as the measurement accuracy is not altered to a great extent. In the same way, the filtering operations can be performed at different instants during the process.

Fig. 5 depicts the steps for collecting and correlating the measurements by a collecting module 4.

The latter receives samples of the non-filtered combinations (class, date, signature) originating from all of the observing probes 2_i attached therewith ;

- each packet is theoretically seen by two observing probes 2i : the first time when entering the network, the second time when leaving. However, other situations may occur. For instance, one packet might be seen only once if the supervision domain is not closed, or more than twice if there are observing probes 2i within the network ;
- each time a packet has been observed by an observing probe 2i as passing by, one combination (class, date, signature) is received by the collecting module 4, except when filtering, sampling or loss of return message, etc…, is taking place ;
- the collecting module 4 correlates the combinations (class, date, signature) for the same packet, for instance by comparing between the signatures and by increasing the transit delays in the network ;
- in case of success, it infers from above, through a simple arithmetical calculation, on one hand, the transfer duration between the different observing probes 2i for the packet in question and, on the other hand, the number of packets that were possibly lost in the network. Moreover, a number of packets in excess at the exit enables to indicate that a fault in one of the network devices or an intrusion attempt has occurred. More sophisticated calculations, such as mean, minimum, maximum, median, etc…, values for a given time slot and a certain flow type, can also be achieved in the collecting module 4 prior to the storage operation

in the storage module 5.

The selection of one set of consistent criteria for the filtering and the static and dynamic sampling that are applicable to all of the observing probes 2_i attached to a collecting module 4 facilitates the correlation operations the latter has to perform, and enhances the successful correlation ratio.

According to an alternative of the method, it may happen that measuring certain flows is not desirable. In this case, corresponding measurements are filtered, which prevents undue loads on the probes 2_i to be generated.

For each packet, one ticket is issued and typically comprises 3 parts : the packet passage time, the packet signature, and the value of the counter associated with the flow (absolute value, or number of packets since the last ticket was issued). For a given flow, tickets are brought together in a common structure before their transmission to the collecting module 4. This clustering operation allows to factorize long elements (flow identifier), and thereby to reduce the overall amount of information to be sent up to the collecting module 4. A transmission of ticket records towards said collecting module 4 is occurring, for instance, if the maximum record length has been reached, or off-time, when, for a given flow, the probes 2_i do not observe packet passing by any longer.

An important advantage of the method according to the invention derives from the fact that flows of ticket records between the probes and the collecting module 4 remain small compared to the amount of measured flows. This enables notably the supervision of large size networks, and possibly the use of the network being supervised itself for sending information between the probes 2_i and the collecting modules 4.

That reduction is achieved notably by the

fact that tickets feature a relatively small size compared to the mean size of the observed packets as this was mentioned here above, and thanks to the sampling of the measured packets, which is effective to limit the number of tickets transmitted to the collecting module 4.

That sampling consists, within one flow, and therefore after classification, in selecting the packets which will cause a ticket to be transmitted. Those tickets which are not selected are simply counted. The sampling criteria may be modified, however in order that the collecting module 4 be able to perform subsequent input/output correlations, it is important they should be common to all of the probes 2_i in the same collecting module 4. Actually, if this was not the case, the likelihood to have a ticket both at the entry and at the exit of the observation domain would be very low for the same packet, and thus the successful correlation ratio would be very low as well. Further, these criteria must be relevant to the binary contents of the packets, which constitutes the sole "absolute" information that is provided on principle.

Criteria and parameters that are possibly associated may be different for each flow. A sampling that suits each type of flow is made possible. For instance, in the case where an Internet network is used, it is possible to provide a higher sampling rate for packets conveying voice (mean compression, high accuracy), while a lower rate will be devoted to data packets (high compression, mean accuracy).

Based on packet signature analysis, one exemplary criterion can be retained : the packets, the signatures of which are multiple of a given value, will be sampled. Of course, any other appropriate arithmetical expression can be used without departing from the scope of the invention.

It is to be noted that sampling do not reduce the counting accuracy. This is equally true when packets are lost, that otherwise would have cause tickets to be issued. Actually, the counter that is associated with every ticket produced yields the total number of packets since the last sampled ticket. The only consequence is a loss of accuracy as for the precise instant at which the loss occurred and the exact identity of the packet that was lost. Both characteristics are of little usefulness a priori, thus being not much looked after. However, as the sampling characteristics are attached to a certain flow, it is always possible not to sample the flows for which detailed information are desirable. For those flows, all of the packets will cause one ticket to be issued. Moreover, as the number of measurements is lower than the number of packets, statistical laws will be applicable, that are well known as for the validity and the accuracy of the measurements which are applied to the sample thus captured.

Therefore, the method according to the invention enables to achieve flow control at the probe level in order :

- to protect the collecting module 4 against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size, …);
- to protect the probes 2i against an overload : (too many tickets to be processed relatively to its own resources that are the available processing power and the memory size, …) ;
- to protect the network used to transmit ticket records from the probe to the collector ;
- to adapt to changes in the capacity of the network used to transmit ticket records from the probes 2i to the collecting module 4 ;

- to enable an optimum distribution of the measurement resource between the different flows in case of congestion ;
- to optimize the pair (measurement accuracy/network load) in accordance with combined criteria, in normal operation.

To control the flow, the following functions may be used, separately or in combination :

- limitation of the overall flow through the network to a maximum value due to the transmission of ticket records from the probes 2i to the collecting module 4. That limit can, either be defined by an initial configuration, or be modulated by the collecting module 4 or by an external device operating the network ;
- limitation of the sampling rate to a maximum value. That limit can, either be defined by an initial configuration, or be provided by the collecting module 4 or by an external device operating the network. In addition, it may differ for each type of flow or flow group ;
- reduction of the sampling rate. That reduction can, either be defined locally by observing the congestion of the probes 2i, or be fixed by the collecting module 4 or by an external device operating the network. That reduction may differ for each type of flow or flow group. The reduction law must allow the collecting module 4 to correlate records which were performed by probes 2i having not the same sampling value for a given flow, the reduction being not necessarily synchronous between the probes 2i. A principle which must be retained is the inclusion one ; tickets of the "reduced" flows have to be included also in the tickets of the "lesser reduced" flows. In this way, tickets of the probe 2_i having the highest reduction factor

can always be correlated with tickets of the probe 2_i having a lower reduction coefficient ;

- modulation of the sampling rate in accordance with the local congestion state at the probe 2_i, the characteristics of the tickets brought back to the collecting module 4, and the load distribution among the different types of flow. An object of that modulation is to secure the probes 2_i operation through adaptation to instant load conditions of the different components in the system. It handles the evolution between a "bad" state corresponding to a low accuracy and a high produced traffic and an "excellent" state corresponding to a high accuracy and a low produced traffic. The evolution between the "bad" and "excellent" zones can be varied.

The main functions of the collecting module 4 are depicted in Fig. 5. The respective order of these functions can be changed according to the different requirements put on the implementation, without departing from the scope of the invention.

The formula here below are carried out by the calculation function of the collecting module 4 for a given flow F.

The notations being used are :

$D_{es}(p)$ = Transfer duration from the entry point (e) to the exit point (s) for a packet (p).

Te(p) = Ticket associated with the packet (p) by the probe at the entry point.

Ts(p) = Ticket associated with the packet (p) by the probe at the exit point.

He(p) = Time stamping in the ticket associated with the packet (p) by the probe at the entry point.

Hs(p) = Time stamping in the ticket associated with the packet (p) by the probe at the exit

point.

Ce(p) = Counter in the ticket associated with the packet (p) by the probe at the entry point.

Cs(p) = Counter in the ticket associated with the packet (p) by the probe at the exit point.

Ne(pq) = Number of packets between the passage of the packets p and q at the entry point.

Ns(pq) = Number of packets between the passage of the packets p and q at the exit point.

Pes(pq)= Number of packets lost between the passage of the packet p and the packet q.

The measurements of the transfer durations are carried out as follows :

For each pair of tickets (Ts(p) ; Te(p)) corresponding to the same packet (p) passing through the observed network, the transfer duration $D_{es}(p)$ can deduced simply from :

$$D_{es}(p) = Hs(p) - He(p)$$

Counting the packets is performed as follows:

let the pairs of tickets (Ts(p) ; Te(p)) and (Ts(q) ; Te(q)) corresponding to the packets (p) and (q) that belong to the same flow and pass through the observed network, and such that the ticket Ts(q) succeeds to the ticket Ts(p) for the probe 2_i at the exit point.

The number Ns(pq) of packets between the passage of the packets p and q at the exit point can be deduced simply from the definition of the counter associated with the exit ticket :

$$Ns(pq) = Cs(q)$$

The number Ne(pq) of packets between the passage of the packets p and q at the entry point equals to the sum of the counters of the entry tickets as for the one associated with p (not included) and the

one associated with q (included). This enables to take into account, for instance, the case where packets are lost, that otherwise would have cause one exit ticket to be issued:

$$Ne\ pq = \sum_{i=p+}^{i=q} Ce\ i$$

Counting the lost packets is performed as follows:

The number Pes(pq) of packets lost in the network between the pass system of the packets p and q then equals to :

$$Pes(pq) = Ne(pq) - Ns(pq)$$

As an example of the implementation of the method according to the invention, Fig. 6 shows schematically an exemplary network in which the entry probe is S_A, and the exit probe is S_B. These probes are already synchronized and have a common time reference. The sampling criterion keeps packets of which the signature equals to 0 module 16. The signature has 2 digits, while time stamping has 4 digits. Time unit is not defined.

Figures 7 to 15 depict different cases where the same packet sequence at the entry is considered, giving rise to the same ticket sequence by the probe S_A.

According to a particular embodiment of the invention as shown in Fig. 16, that is adapted to the case where the sampling rate is low, i.e. when numerous packets do not cause one ticket to be transmitted, for a given flow, time is broken down in slots, starting from the instant when an observed packet caused one last ticket to be issued. The size of the slot can be fixed locally at the probe or by the collector, and may

change according to different criteria ;

- one counter is associated with each time slot ;
- for every packet passing by that does not cause one ticket to be issued, the counter associated with the corresponding time slot when the passage occurred is incremented ;
- and for the next packet passing by that causes one ticket to be issued, the list of counters thereby obtained is attached.

That mechanism enables the collecting module 4 to obtain, by comparing between the counters provided by the probes 2_i at the entry and at the exit, a measurement of the change in transfer durations for packets flowing between packets that cause tickets to be issued and that are subjected thus to an overall measurement. It is also assumed that packets belonging to the same flow do not become a pair, which is generally the case.

The accuracy obtained has a value of about the length of the time "slot" that was retained (compromise between the number of slots - thus of counters to be flowed up - and the accuracy).

It is to be noted that this mechanism can work out well but as long as the packet loss rate is null or low for the period of time which is considered.

The main advantages of this embodiment are the following :

- refining the delay measurement : packets that did not cause one ticket to be issued still contribute to the measurement ;
- insensitivity to a rise in the number of packets observed : an increase in the number of packets observed will not actually result in an increase of the traffic flowing back from the probes 2i to the collecting module 4.

CLAIMS

1. Non-intrusive method for measuring the loss rates and transfer durations for data in a telecommunication network in packet mode, characterized in that it comprises the following steps:

- the classification of the data packets in a homogenous flow ;
- the calculation of an identification signature for each data packet ;
- the counting of the packets in the flow ;
- the measurement of the unidirectional transfer durations per flow or information flow group, on one hand, and measurement of the loss rate for the packets, on the other hand.

2. Method according to claim 1, characterized in that each packet is subjected to dating in accordance with an absolute time reference gained by observing the probes (2_i) distributed through the network.

3. Method according to claim 2, characterized in that one ticket comprising the packet passage time, the packet signature, and the value of a counter associated with the flow or the flow group is issued.

4. Method according to one of claims 1 to 3, characterized in that it further comprises a filtering step and a semi-static sampling step for classes obtained during the classification step, that sampling consisting in selecting the packets which will cause one ticket to be issued.

5. Method according to one of claims 1, 2 or 3, characterized in that it comprises a dynamic

sampling step with a rate which depends of the congestion conditions in the system.

6. Method according to claim 1, characterized in that each packet is classified according to its recipient characteristics or according to the type of its contents.

7. Method according to one of claims 1 to 4, characterized in that the sampling rate can, either be limited to a maximum value that is defined by an initial configuration, or be modulated by the collecting module (4) or by an external device operating the network (1).

8. Method according to one of claims 1 to 7, characterized in that, for a given flow F, the measurement of the transfer durations is carried out as follows :

$$D_{es}(p) = Hs(p) - He(p)$$

where

$D_{es}(p)$ = Transfer duration from the entry point (e) to the exit point (s) for a packet (p).

He(p) = Time stamping in the ticket associated with the packet (p) by the probe at the entry point.

Hs(p) = Time stamping in the ticket associated with the packet (p) by the probe at the exit point.

9. Method according to claim 8, characterized in that the step for calculating the transfer durations at different sections in the network is carried out by a mapping operation of combinations (class, date, signature) which belong to the same packet that was observed by several probes (2_i).

10. Method according to claim 8, characterized in that, for a given flow F, the number Pes(pq) of packets lost in the network between the passage of the packets p and q is given by the following formulae :

$$Pes(pq) = Ne(pq) - Ns(pq)$$

where

Ne(pq) = Number of packets between the passage of the packets p and q at the exit point.

Ns(pq) = Number of packets between the passage of the packets p and q at the exit point.

11. Method according to claim 5, characterized in that, in the case where the sampling rate is low, time is broken down in slots, starting from the instant when an observed packet caused one last ticket to be issued, the size of the slot can be fixed locally at the probe (2_i) or by the collecting module (4), one counter is associated with each time slot, and for every packet passing by that does not cause one ticket to be issued, the counter associated with the corresponding time slot when the passage occurred is incremented, and for the next packet passing by that causes one ticket to be issued, the list of counters thereby obtained is attached.

12. System with a distributed architecture for implementing the method according to one of claims 1 to 11, said system comprising a plurality of flow observing probes (2_i) arranged in several locations in the network (1), means for compressing measurements carried out by said observing probes (2_i), and means for transmitting these measurements to a module (4) collecting measurements carried out and which is connected to storage means (5) and means (6) for

analyzing said measurements, characterized in that it further comprises means for classifying data packets in a homogenous flow, means for calculating an identification signature for each data packet, means for counting the packets in the flow, and means for measuring, on one hand, the unidirectional transfer durations per flow or information flow group, and, on the other hand, the loss rate for the packets.

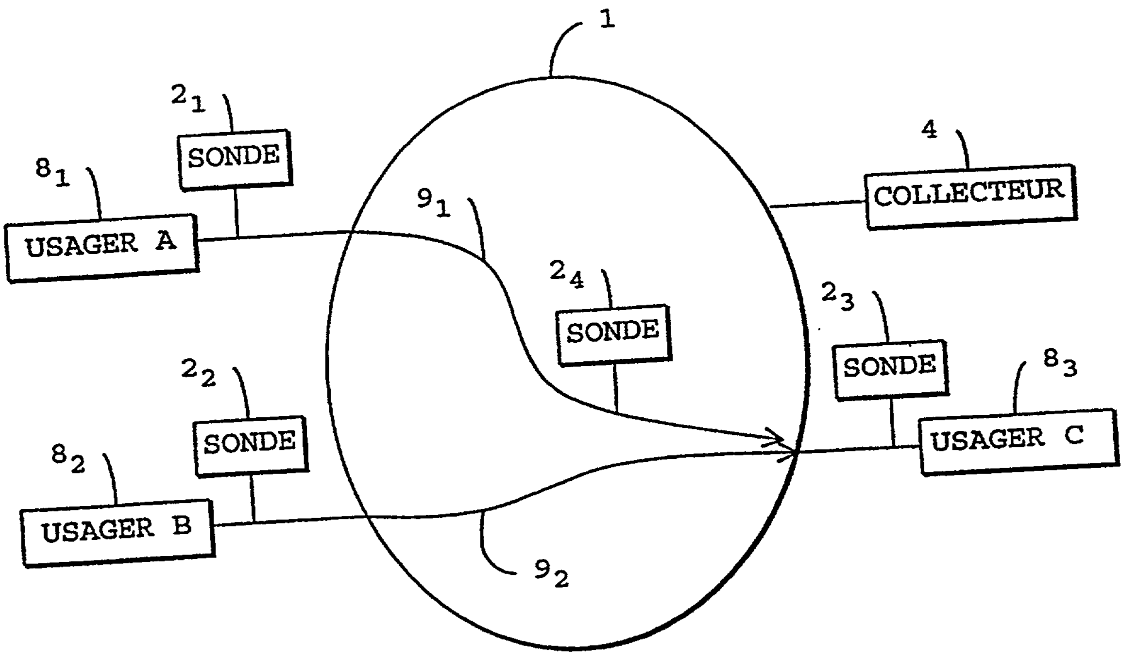

1
2₁
SONDE
8₁
USAGER A
9₁
2₄
SONDE
4
COLLECTEUR
2₃
SONDE
8₃
USAGER C
2₂
SONDE
8₂
USAGER B
9₂

FIG1

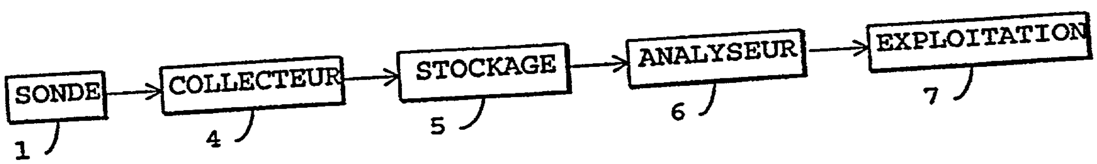

SONDE
1
COLLECTEUR
4
STOCKAGE
5
ANALYSEUR
6
EXPLOITATION
7

FIG 2

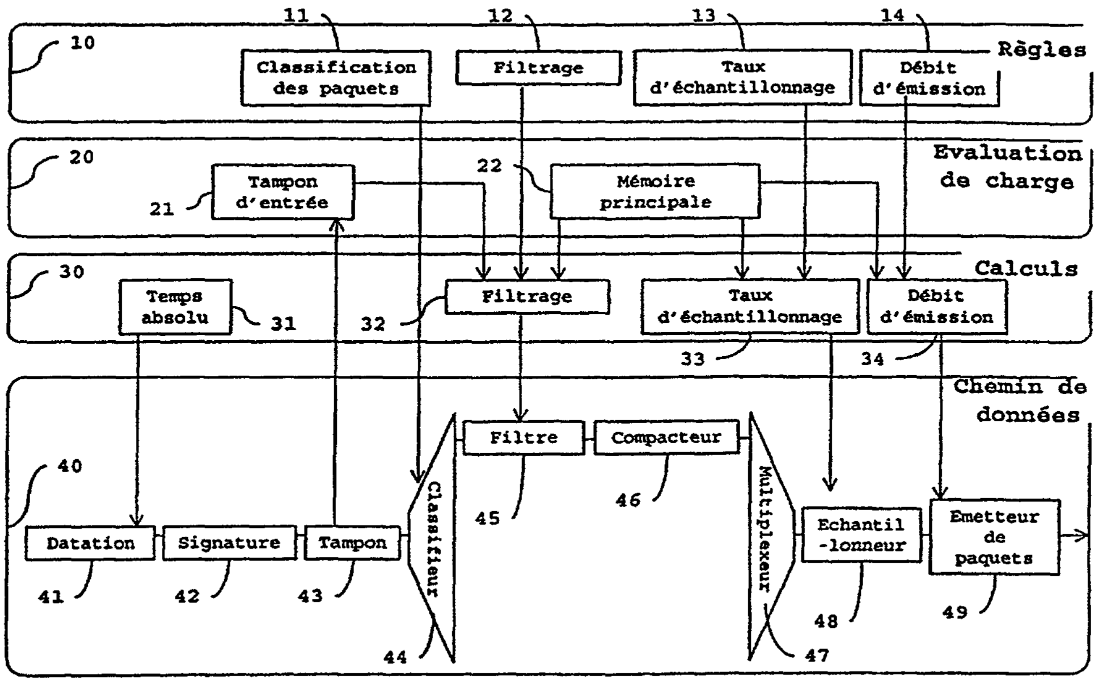

Règles
10
11
Classification des paquets
12
Filtrage
13
Taux d'échantillonnage
14
Débit d'émission
Evaluation de charge
20
21
Tampon d'entrée
22
Mémoire principale
Calculs
30
Temps absolu
31
32
Filtrage
Taux d'échantillonnage
33
Débit d'émission
34
Chemin de données
40
Datation
41
Signature
42
Tampon
43
Classifieur
44
Filtre
45
Compacteur
46
Multiplexeur
47
Echantil -lonneur
48
Emetteur de paquets
49

FIG 3

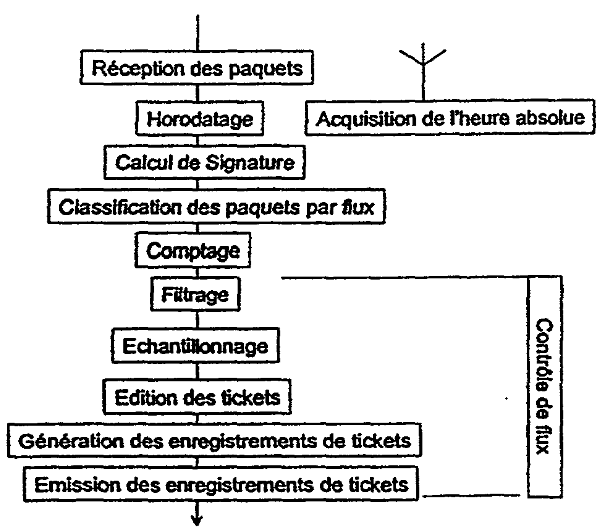

Réception des paquets
Horodatage
Acquisition de l'heure absolue
Calcul de Signature
Classification des paquets par flux
Comptage
Filtrage
Echantillonnage
Edition des tickets
Génération des enregistrements de tickets
Emission des enregistrements de tickets
Contrôle de flux

FIG 4

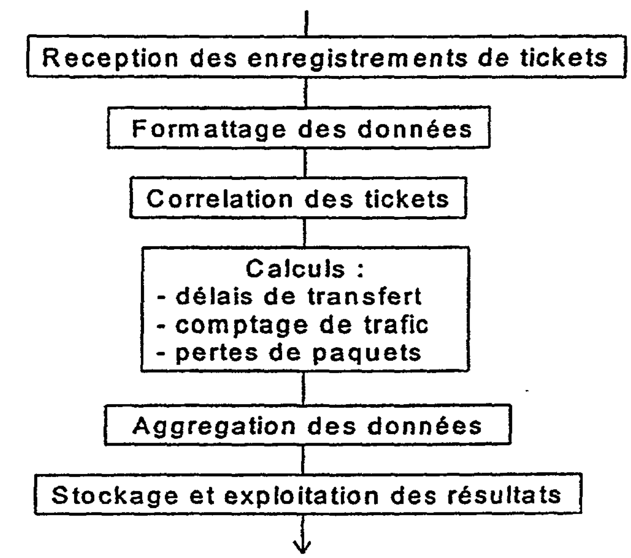

Reception des enregistrements de tickets
Formattage des données
Correlation des tickets
Calculs :
- délais de transfert
- comptage de trafic
- pertes de paquets
Aggregation des données
Stockage et exploitation des résultats

FIG 5

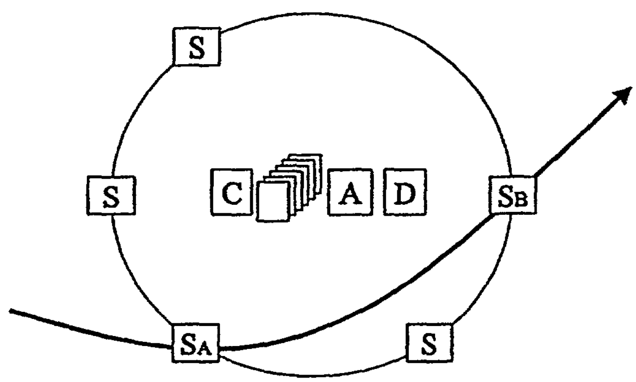
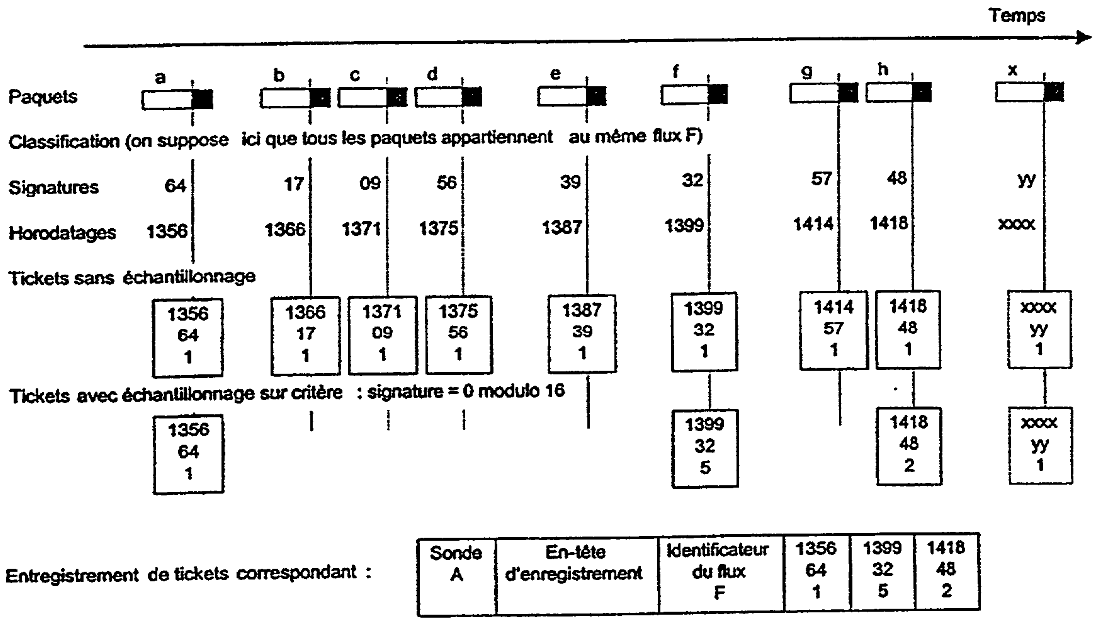
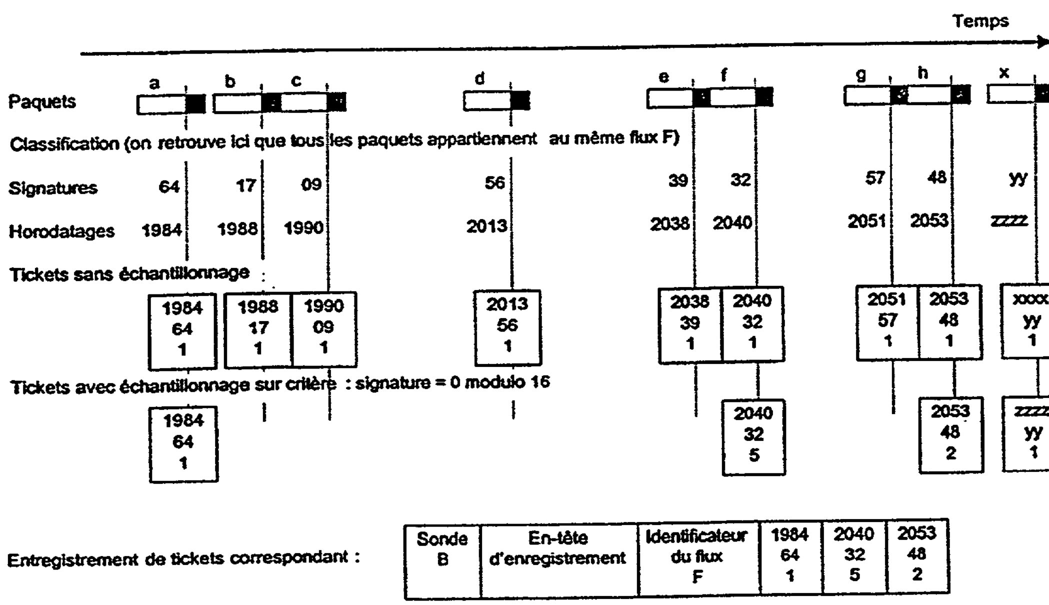

S
S
C
A
D
SB
SA
S

FIG 6



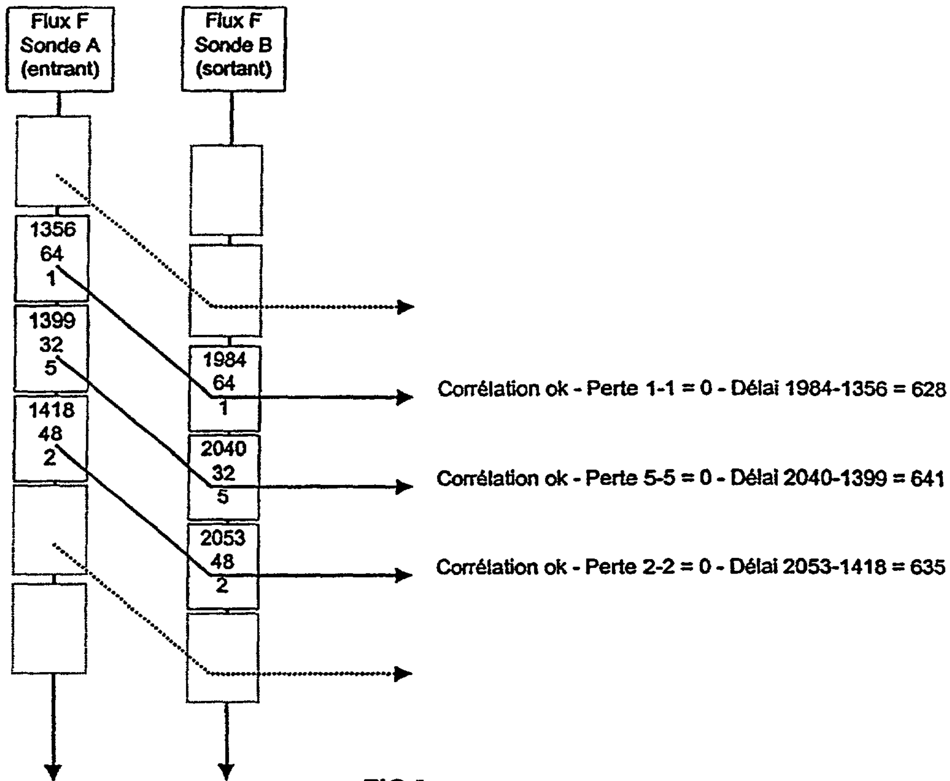
Temps
Paquets
a
b
c
d
e
f
g
h
x
Classification (on suppose ici que tous les paquets appartiennent au même flux F)
Signatures 64 17 09 56 39 32 57 48 yy
Horodatages 1356 1366 1371 1375 1387 1399 1414 1418 xxxx
Tickets sans échantillonnage
1356 64 1
1366 17 1
1371 09 1
1375 56 1
1387 39 1
1399 32 1
1414 57 1
1418 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1356 64 1
1399 32 5
1418 48 2
xxxx yy 1
Entregistrement de tickets correspondant :
Sonde A
En-tête d'enregistrement
Identificateur du flux F
1356 64 1
1399 32 5
1418 48 2

FIG 7



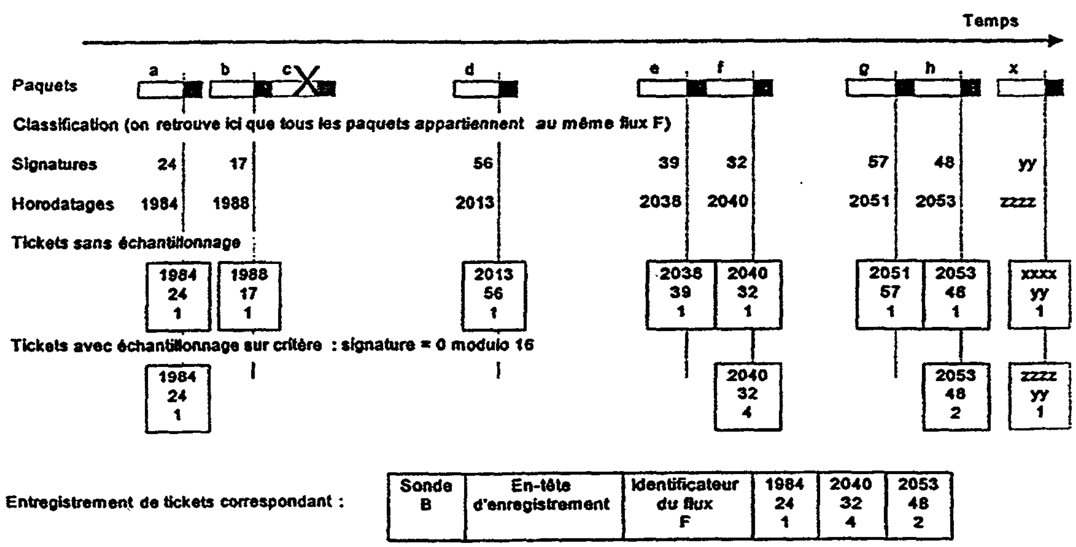
Temps
Paquets
a
b
c
d
e
f
g
h
x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures 64 17 09 56 39 32 57 48 yy
Horodatages 1984 1988 1990 2013 2038 2040 2051 2053 zzzz
Tickets sans échantillonnage :
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2040 32 1
2051 57 1
2053 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1984 64 1
2040 32 5
2053 48 2
zzzz yy 1
Entregistrement de tickets correspondant :
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2040 32 5
2053 48 2

FIG 8



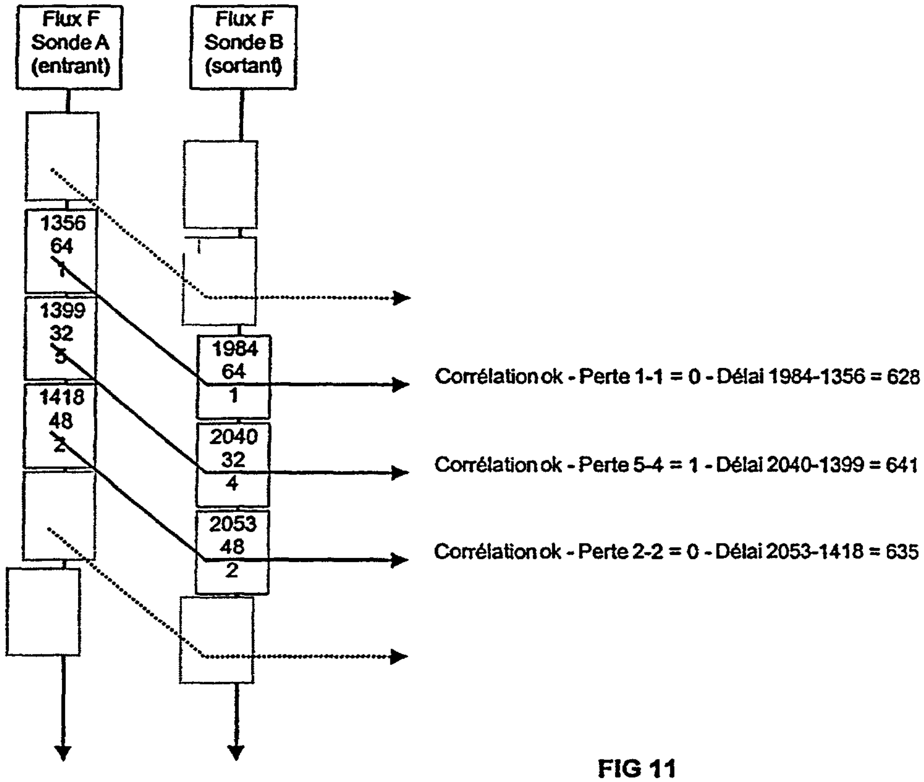
Flux F
Sonde A
(entrant)
Flux F
Sonde B
(sortant)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2040
32
5
2053
48
2
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte 5-5 = 0 - Délai 2040-1399 = 641
Corrélation ok - Perte 2-2 = 0 - Délai 2053-1418 = 635

FIG 9



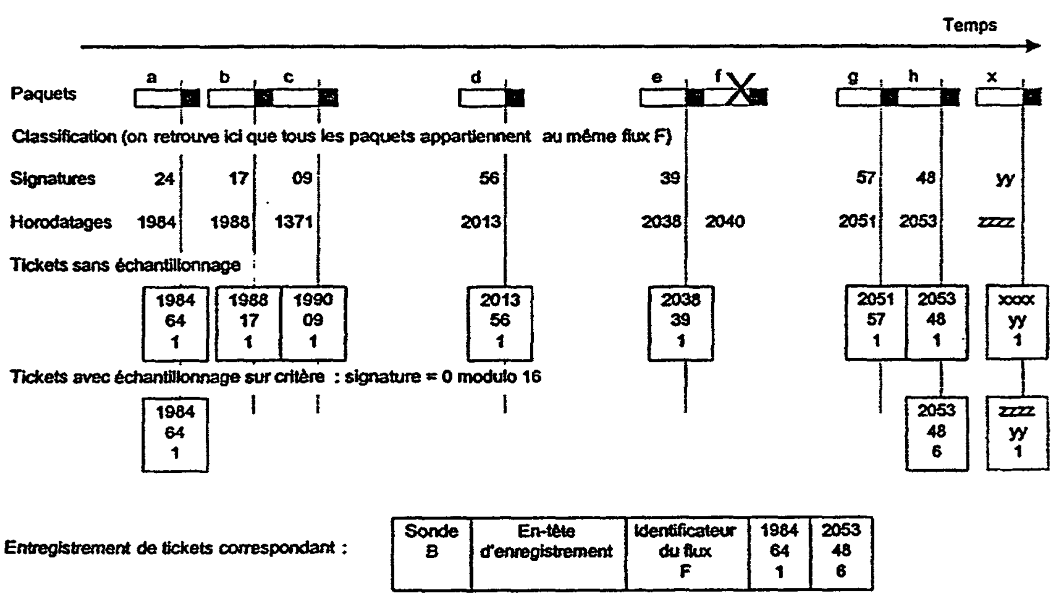
Temps
Paquets
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures
Horodatages
Tickets sans échantillonnage
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
Entregistrement de tickets correspondant :
Sonde B
En-tête d'enregistrement
Identificateur du flux F

FIG 10



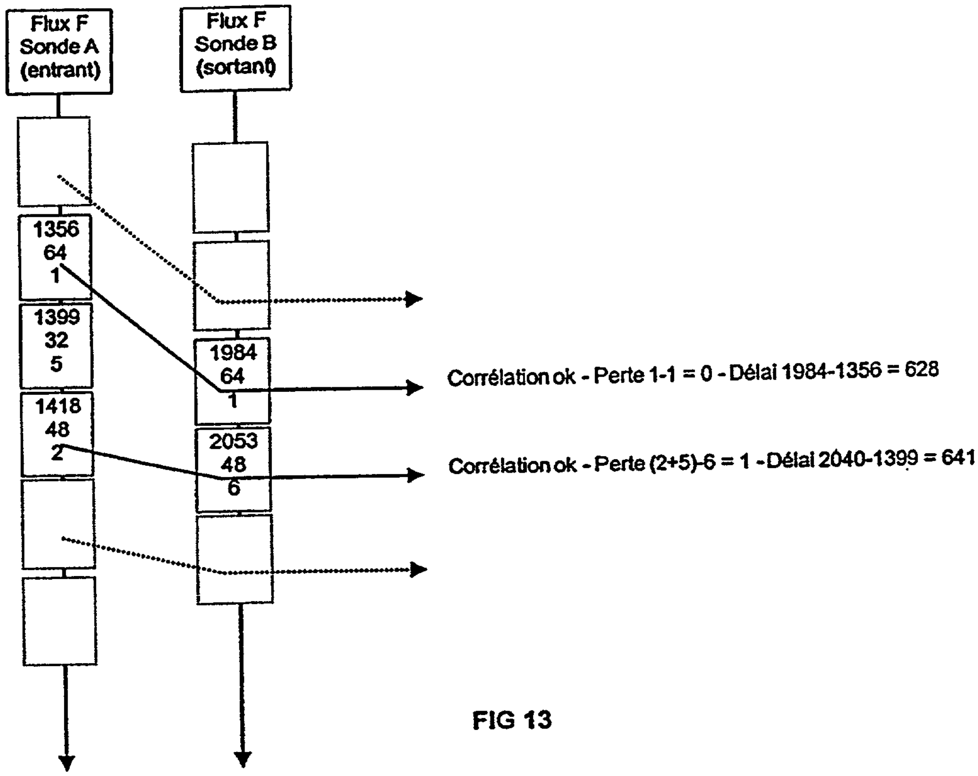
Flux F
Sonde A
(entrant)
Flux F
Sonde B
(sortant)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2040
32
4
2053
48
2
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte 5-4 = 1 - Délai 2040-1399 = 641
Corrélation ok - Perte 2-2 = 0 - Délai 2053-1418 = 635

FIG 11



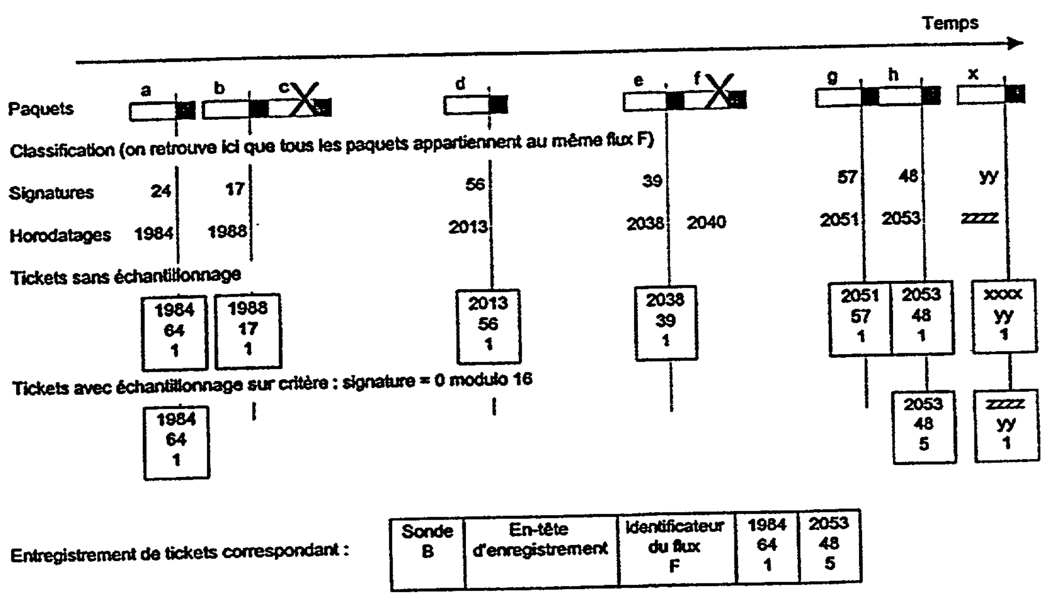
Temps
Paquets
a b c d e f g h x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures 24 17 09 56 39 57 48 yy
Horodatages 1984 1988 1371 2013 2038 2040 2051 2053 zzzz
Tickets sans échantillonnage
1984 64 1
1988 17 1
1990 09 1
2013 56 1
2038 39 1
2051 57 1
2053 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1984 64 1
2053 48 6
zzzz yy 1
Entregistrement de tickets correspondant :
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2053 48 6

FIG 12



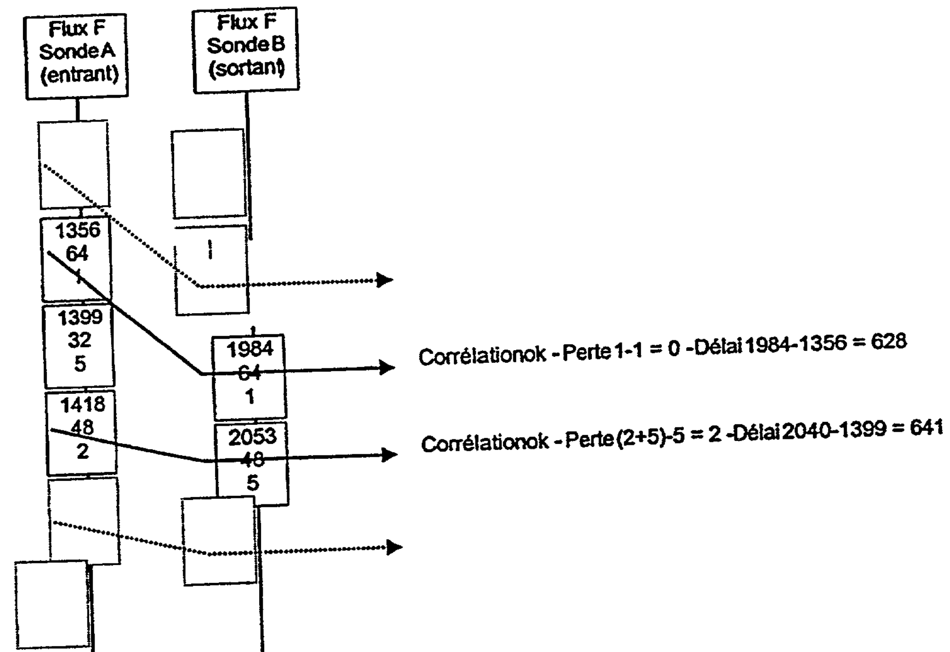
Flux F Sonde A (entrant)
Flux F Sonde B (sortant)
1356 64 1
1399 32 5
1418 48 2
1984 64 1
2053 48 6
Corrélation ok - Perte 1-1 = 0 - Délai 1984-1356 = 628
Corrélation ok - Perte (2+5)-6 = 1 - Délai 2040-1399 = 641

FIG 13



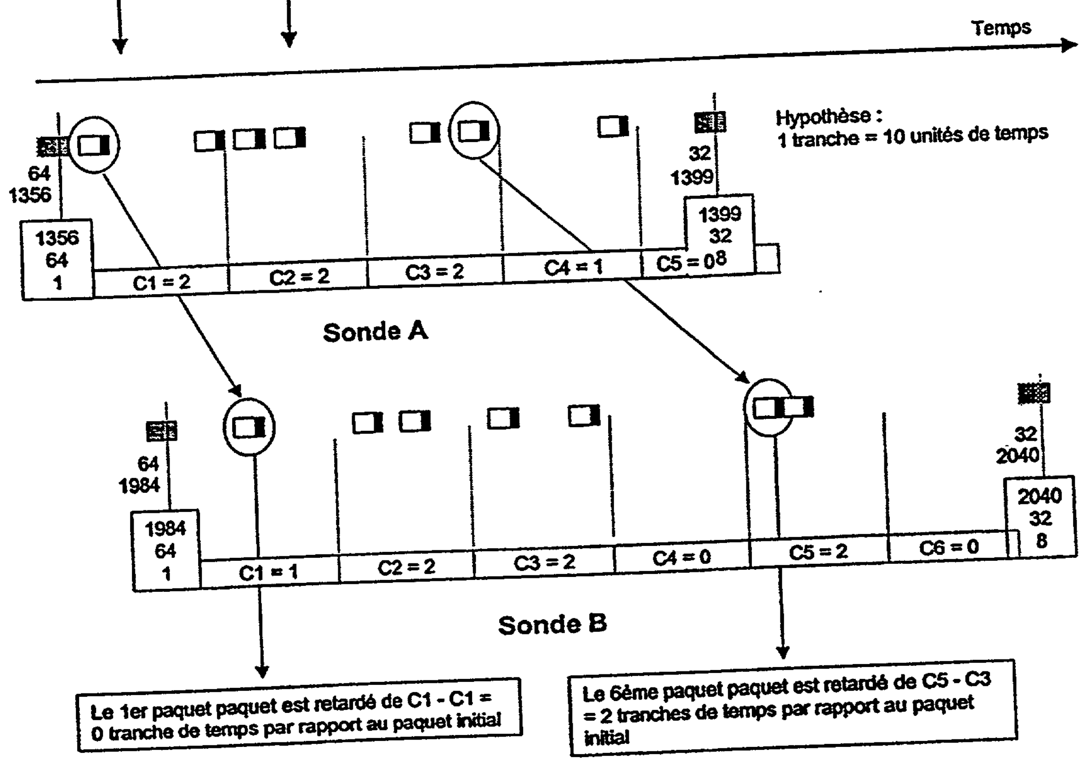
Temps
Paquets
a
b
c
d
e
f
g
h
x
Classification (on retrouve ici que tous les paquets appartiennent au même flux F)
Signatures
24
17
56
39
57
48
yy
Horodatages
1984
1988
2013
2038
2040
2051
2053
zzzz
Tickets sans échantillonnage
1984 64 1
1988 17 1
2013 56 1
2038 39 1
2051 57 1
2053 48 1
xxxx yy 1
Tickets avec échantillonnage sur critère : signature = 0 modulo 16
1984 64 1
2053 48 5
zzzz yy 1
Entregistrement de tickets correspondant :
Sonde B
En-tête d'enregistrement
Identificateur du flux F
1984 64 1
2053 48 5

FIG 14



Flux F Sonde A (entrant)
Flux F Sonde B (sortant)
1356
64
1
1399
32
5
1418
48
2
1984
64
1
2053
48
5
Corrélationok - Perte 1-1 = 0 -Délai 1984-1356 = 628
Corrélationok - Perte (2+5)-5 = 2 -Délai 2040-1399 = 641

FIG 15



Temps
Hypothèse :
1 tranche = 10 unités de temps
64
1356
1356
64
1
C1 = 2
C2 = 2
C3 = 2
C4 = 1
C5 = 08
32
1399
1399
32
Sonde A
64
1984
1984
64
1
C1 = 1
C2 = 2
C3 = 2
C4 = 0
C5 = 2
C6 = 0
32
2040
2040
32
8
Sonde B
Le 1er paquet paquet est retardé de C1 - C1 = 0 tranche de temps par rapport au paquet initial
Le 6ème paquet paquet est retardé de C5 - C3 = 2 tranches de temps par rapport au paquet initial

FIG 16

USSN 09/914,335

Practitioner's Docket No. 01-515 **PATENT**

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION, OR C-I-P)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

(check one applicable item below)

☐ original.

☐ design.

☐ supplemental.

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

XX national stage of PCT.

NOTE: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

NOTE: See 37 C.F.R. § 1.63(d) (continued prosecution application) for use of a prior nonprovisional application declaration in the continuation or divisional application being filed on behalf of the same or fewer of the inventors named in the prior application.

☐ divisional.

☐ continuation.

NOTE: Where an application discloses and claims subject matter not disclosed in the prior application, or a continuation or divisional application names an inventor not named in the prior application, a continuation-in-part application must be filed under 37 C.F.R. § 1.53(b) (application filing requirements — nonprovisional application).

☐ continuation-in-part (C-I-P).

INVENTORSHIP IDENTIFICATION

WARNING: *If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.*

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

SYSTEM AND METHOD FOR MEASURING THE TRANSFER DURATIONS AND LOSS RATES IN HIGH VOLUME TELECOMMUNICATION NETWORKS

SPECIFICATION IDENTIFICATION

the specification of which:

(complete (a), (b), or (c))

(a) ☐ is attached hereto.

NOTE: "The following combinations of information supplied in an oath or declaration filed on the application filing date with a specification are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 CFR 1.63:

"(1) name of inventor(s), and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration on filing;

"(2) name of inventor(s), and attorney docket number which was on the specification as filed; or

"(3) name of inventor(s), and title which was on the specification as filed."

Notice of July 13, 1995 (1177 O.G. 60).

(b) ☐ was filed on ________________, as ☐ Serial No. 0 /________
or ☐ ________________________
and was amended on ____________ *(if applicable).*

NOTE: Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 C.F.R. § 1.67.

NOTE: "The following combinations of information supplied in an oath or declaration filed after the filing date are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 CFR 1.63:

"(A) application number (consisting of the series code and the serial number, e.g., 08/123,456);

"(B) serial number and filing date;

"(C) attorney docket number which was on the specification as filed;

"(D) title which was on the specification as filed and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration; or

"(E) title which was on the specification as filed and accompanied by a cover letter accurately identifying the application for which it was intended by either the application number (consisting of the series code and the serial number, e.g., 08/123,456), or serial number and filing date. Absent any statement(s) to the contrary, it will be presumed that the application filed in the PTO is the application which the inventor(s) executed by signing the oath or declaration."

M.P.E.P. § 601.01(a), 7th Ed.

(c) ☒ was described and claimed in PCT International Application No. PCT/FR00/00311, filed on February 9, 2000 and as amended under PCT Article 19 on ____________ *(if any).*

(Declaration and Power of Attorney [1-1]—page 2 of 7)

SUPPLEMENTAL DECLARATION (37 C.F.R. § 1.67(b))

(complete the following where a supplemental declaration is being submitted)

☐ I hereby declare that the subject matter of the

☐ attached amendment

☐ amendment filed on ________________

was part of my/our invention and was invented before the filing date of the original application, above-identified, for such invention.

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

(also check the following items, if desired)

☒ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 C.F.R. § 1.98.

PRIORITY CLAIM (35 U.S.C. §§ 119(a)–(d))

NOTE: *"The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by § 1.63. The claim for priority and the certified copy of the foreign application specified in 35 U.S.C. 119(b) must be filed in the case of an interference (§ 1.630), when necessary to overcome the date of a reference relied upon by the examiner, when specifically required by the examiner, and in all other situations, before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by a petition requesting entry and by the fee set forth in § 1.17(i). If the certified copy is not in the English language, a translation need not be filed except in the case of interference; or when necessary to overcome the date of a reference relied upon by the examiner; or when specifically required by the examiner, in which event an English language translation must be filed together with a statement that the translation of the certified copy is accurate." 37 C.F.R. § 1.55(a).*

I hereby claim foreign priority benefits under Title 35, United States Code, §§ 119(a)–(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) ☐ no such applications have been filed.

(e) X☒ such applications have been filed as follows.

NOTE: *Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.*

PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 USC 119
FRANCE	99/02399	26/02/1999	☒ YES NO ☐
FRANCE	99/06115	12/05/1999	☒ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐
			☐ YES NO ☐

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)
(34 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER	FILING DATE
_______ /_______________	_______________
_______ /_______________	_______________
_______ /_______________	_______________

CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S) UNDER 35 U.S.C. § 120

☐ The claim for the benefit of any such applications are set forth in the attached ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN PART (C-I-P) APPLICATION.

(Declaration and Power of Attorney [1-1]—page 4 of 7)

ALL FOREIGN APPLICATION(S), *IF ANY*, FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

NOTE: *If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.*

POWER OF ATTORNEY

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

(list name and registration number)

4

Robert H. Bachman (19,374), Gregory P. LaPointe (28,395), Barry L. Kelmachter (29,999), and George A. Coury (34,309), all of Bachman & LaPointe, P.C., 900 Chapel Street, Suite 1201, New Haven, CT 06510-2802

(check the following item, if applicable)

- [X] I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.
- [ ] Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE TO

- [X] Address
  Bachman & LaPointe, P.C.
  900 Chapel Street, Suite 1201
  New Haven, CT 06510-2802
- [ ] Customer Number ____________

DIRECT TELEPHONE CALLS TO:
(Name and telephone number)

Barry L. Kelmachter
(203) 777-6628 - ext. 114

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents.

NOTE: Each inventor must be identified by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial, and by his/her residence, post office address and country of citizenship. 37 CFR § 1.63(a)(3).

NOTE: Inventors may execute separate declarations/oaths provided each declaration/oath sets forth all the inventors. Section 1.63(a)(3) requires that a declaration/oath, inter alia, identify each inventor and prohibits the execution of separate declarations/oaths which each sets forth only the name of the executing inventor. 62 Fed. Reg. 53,131, 53,142, October 10, 1997,

Full name of sole or first inventor

Thierry ____ Grenot

(GIVEN NAME) *(MIDDLE INITIAL OR NAME)* *FAMILY (OR LAST NAME)*

Inventor's signature Thierry Grenot

Date Oct 15th, 2001 **Country of Citizenship** France

Residence 1, cite Leisnier, F-92140 Clamart, FRANCE FRX

Post Office Address (Same As Above)

Full name of second joint inventor, if any

(GIVEN NAME) *(MIDDLE INITIAL OR NAME)* *FAMILY (OR LAST NAME)*

Inventor's signature ____

Date ____ **Country of Citizenship** ____

Residence ____

Post Office Address ____

Full name of third joint inventor, if any

(GIVEN NAME) *(MIDDLE INITIAL OR NAME)* *FAMILY (OR LAST NAME)*

Inventor's signature ____

Date ____ **Country of Citizenship** ____

Residence ____

Post Office Address ____

(check proper box(es) for any of the following added page(s) that form a part of this declaration)

☐ **Signature** for fourth and subsequent joint inventors. *Number of pages added* ________.

* * *

☐ **Signature** by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* ________.

* * *

☐ **Signature** for inventor who refuses to sign or cannot be reached by person authorized under 37 CFR 1.47. *Number of pages added* ________

* * *

☐ Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time. (37 CFR 1.47)

* * *

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application.

☐ Number of pages added ________

* * *

☐ Authorization of practitioner(s) to accept and follow instructions from representative.

* * *

(if no further pages form a part of this Declaration, then end this Declaration with this page and check the following item)

☒ This declaration ends with this page.